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Fauna of the springtails *(Collembola)* of the Ojców National Park in Poland

[Pp. 219—280, 5 text-figs., pls. XVII—XXII]

Fauna skoczogonek *(Collembola)* Ojcowskiego Parku Narodowego

Фауна ногохвосток *(Collembola)* Ойцовского Государственного Заповедника в Польше

Abstract: The paper contains a description of the *Collembola* fauna of the Ojców National Park. The prevalence of 157 species was ascertained, 20 of which were new to the fauna of Poland. On hand of frequency analysis of species in various habitats, several types of them which showed qualitative different *Collembola* fauna were distinguished. Furthermore, species were distinguished by zoogeographical analysis into widely distributed species without special geographical preference, montane species, Boreal-alpine species, southern species, and species of unknown range. On hand of their distribution and ecology, several groups of relicts from various climatic periods were distinguished.

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I. INTRODUCTION

Wingless insects *(Apterygota)*, and amongst them spıingtails *(Collembola)*, belong to a group which is in our country and nearly all Europe still insufficiently known. In spite of STACH's investigations, concluded in his many-volume monograph „The Apterygotan fauna of Poland in relation to the world fauna of this group of insects“, numerous districts of Poland remain still virtually uninvestigated. In view of the great importance of springtails in the nature economy, and especially so in soil biology, arises the necessity of study of both the species composition of the fauna of particular areas and the connection of species with concrete habitats.

This paper is aimed at: 1. Introducing of a list of species which occur in the area of the Ojców National Park, 2. Establishment of connections between the springtail fauna and plant associations in this area, 3. Definition of arrival of certain species of more distinct geographical features in the area of the South Jura.

Synanthropic habitats, cultivated grounds, as well as certain small habitats as, e. g. holes of rodents or bird's nests, were nearly not at all taken into account. The fauna of caves, the cryophilous fauna, and species thriving in winter time, were also rather inaccurately investigated. They will be worked on in future.

In this place, I would like to express my sincere thanks to Prof. Dr. J. STACH and Prof. Dr. J. RAFALSKI for valuable discussions of my paper, to Doc. Dr. W. SZYMCZAKOWSKI for his remarks concerning the zoogeographical part, and to Dr. A. RAJSKI for discussion of the ecological part. I am indebted to Dr. J. RUSEK from Prague for certain information concerning the springtail fauna of the Moravian Karst, and to Dr. P. N. LAWRENCE from the British Museum for lending me specimens of *Orchesella* sp. from the British Isles. At last, I thank M. Sc. S. MICHALIK, and M. Sc. J. KLEIN for very valuable to me data concerning vegetation and climate of the investigated area.

II. INVESTIGATION AREA

The Ojców National Park is situated in the south-eastern part of the Cracow—Wieluń Highland, about 15 km north-west of Cracow (Fig. 1). It includes a part of the Prądnik- and Sąspówka valleys, as well as the adjoining plateau. The valley bottom is 350 m above sea level; the highest elevations exceed 450 m.

The investigated part of the Cracow-Wieluń Highland consists nearly entirely of Jurassic limestone (raurak), covered on extensive areas by Quaternary loess and aboriginal debris loam. Little fragments, indistinct in the landscape of our terrain, consist of Cretaceous deposits (low cenomanian marls).

Already since the Upper Cretaceous or at least from the early Paleogen on, the southern part of the Highland has not been flooded by the sea. During

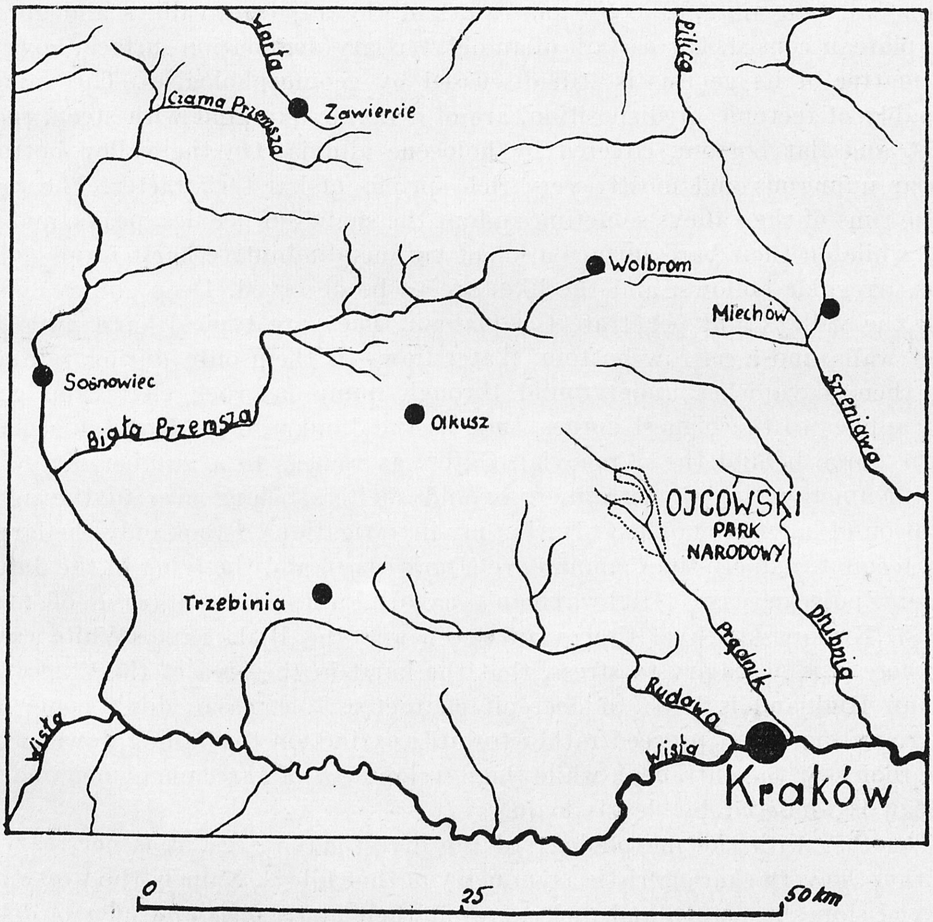


Fig. 1. Localization of the Ojców National Parc (= Ojcowski Park Narodowy).

several successive periods of warm climate erosion acted intensely, and karst phenomena developed, which are dependent on limestone ground. It was then that the basic morphological features of our terrain were developed.

The Pleistocene, apart from the loess cover of which most of the surface of the discussed area is made up, left very few traces here. The southern part of the Cracow-Wieluń Highland was only once covered by the glacier, i. e. during the Cracovian Glaciation (Cracovien, Mindel), and even traces of that glaciation

are rather indistinct. LEWIŃSKI (1913) established prevalence of erratics here, and in the adjacent little valleys, traces of washed apart moraine loam were observed. Unfortunately it was impossible for later authors (ALEKSANDROWICZ and WILK, 1962) to ascertain LEWIŃSKI's data. From the time of the Great Interglaciation on (Masovien I, Mindel — Riss), our terrain was already free of ice, though it certainly found itself several times in the range of periglacial climate [1].

Concerning the relief of the investigated area, it is necessary to distinguish first of all two units; i. e. the plateau, and the adjacent valleys and gorges. The plateau consists for certain of an old, tertiary denudation surface; however the matter of its genesis is still discussed by geomorphologists. The valleys, probably of tectonic predisposition, are of a ravine-like kind with steep, rocky walls, and flat bottom, covered by holocene alluvia. On the valley bottoms appear numerous and mostly very rich springs of karst character. The rocks at the rims of the valleys sometimes adopt the shapes of needles, peaks, and the like; while on their bare surface a lot of various diminutive karst forms (small cribs, irregular hollows, and the like) are to be observed. Deep gorges extend from the valleys and penetrate the plateau. They are typical karst gorges of steep walls and a narrow bottom. Water flows in them only during rainfalls, and then it vanishes underground through numerous rock clefts and gaps. This applies to the biggest gorges, such as the Jamka gorge, Korytania gorge, or the gorge behind the „Cracovian Gate", as well as to a number of smaller ones. Numerous in our terrain caves and shelters belong also to the agglomeration of karst phenomena. During my investigations, I took only the largest into account, namely the Ciemna cave (Dark cave), and the lying in the Jamka gorge: Zbójecka cave (Highwayman's cave), Piętrowa cave (cave of many floors), Krakowska cave (Cracovian cave), and the Biała cave (White cave). But here it is necessary to stress, that the karst in the area of the Cracovian-Wieluń Highland is karst of decrepit character. I. e. caves don't come into being any more and proceed rather towards extinction (by falling down of the cave roof near the entrance), while the development of karst phenomena on the plateau is hindered by debris loam.

Together with the morphology of the investigated area, it is necessary to mention the very characteristic asymmetry of the valleys. Namely the westwards exposed slopes are steep and rocky, and at their foot, cones and piles of debris accumulate, whereas the opposite slopes are significantly more gentle and generally covered by a thick layer of loess. The genesis of this phenomenon is still insufficiently known [2].

The general climate of Ojców was not investigated up to now, however

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[1] Accurate data concerning the geology, and more so, hydrogeology of Ojców, as well as further literature, may be found in the cited paper by ALEKSANDROWICZ and WILK (1962).

[2] One may find a detailed discussion of the morphology of Ojców in the paper of DRZAŁ, 1954.

in connection with a serious microclimatic differentiation, it has relatively small bearing on the fauna of the investigated area.

Concerned with microclimatic differentiation were recently Klein and Niedźwiedź (1965). They mainly observed enormous differences in insolation (ranging 45 %), as well as connected with these, differences of temperature, relative air humidity, and thickness, as well as rate of disappearance, of snow cover. The differences in relative air humidity and temperature for two opposite slopes of the Sąspówka valley are shown in Tabl. I (data from April 7th 1963).

Table I

Measured at height of	Temperature in °C. 150 cm	15 cm	1 cm	Relative air humidity % 150 cm	15 cm	1 cm
beech stand	5·8°	2·5°	1·4°	57	82	88
xerothermic grassland	12·5°	21·0°	31·4°	37	22	19

In addition to insolation, also the descent and stagnation of cold air into valley bottoms and the resulting microclimatic inversion are of certain importance.

On hand of investigations conducted by themselves, the cited authors distinguished in the area of Ojców 4 microclimatic „sectors".

I. The cool sector of the valley bottom is characterized by large temperature amplitudes in 24 hrs course, frequent occurrence of radiation fog, and reluctant disappearance of snow cover.

II. The cold sector of the valley slopes exposed towards N., NE., and NW., is first of all characterized by very poor insolation. The resulting temperatures are here by 2—6° lower, and relative air humidity 10—20 % higher as on opposite slopes; snow cover stays significantly longer.

III. The warm sector of valley slopes includes slopes which are exposed towards S., SW., and SE., and is characterized by significantly greater insolation and thus resulting higher temperatures, as well as lower relative air humidity. The snow cover disappears several weeks earlier than on opposite slopes. Certain differences between positions overgrown by xerothermic brushwood, and xerothermic grassland, which in our terrain present the driest and warmest media, appear in this sector.

IV. The temperate sector of flat plateaus, which is mainly characterized by great constancy of temperatures and relative air humidity.

Even the schem presented here doesn't reflect the whole variety of microclimatic conditions which prevail in our terrain. Sometimes in the span of

literally a few meters prevail extreme thermical and humidity conditions; from the dry and insolated xerothermic grassland, — to the moist and cool, covered by mosses and lichens, rock wall.

Soil types, acc. to unpublished data by Greszta and Bitka (material available at the Management of the Ojców National Park) are rather slightly differentiated. They represent several types of rendzina, brown soils, and podzolic soils. The rendzina never develops in its pure state, i. e. it is found only on limestone debris, but always more or less impured by loess admixture. It develops generally on the slopes of valleys; on plateau only on outcrops of limestone rocks. Brown soils develop on shallow loess of down to 1 m depth, whereas podzolic soil develops on deeper loess. Gleization occurs very locally in a few places only. The valley bottoms consist of brown soil of alluvial origin.

Soil acidity depends closely on the terrain relief. The slopes of valleys and outcrops of limestone on plateau are covered by soil of the higher pH, whereas the covered by a thick coating of loess soils of plateau are the most acid.

There seems to be no close connection between the soil type and some concrete plant association. This results probably from the fact that the soil type is mainly determined by the thickness of the loess coating; the vegetation of a certain plot mainly by its microclimate; while both these phenomena don't fit accurately.

The differentiation of relief and microclimate causes enormous abundance of flora and fauna. The number of solely vascular plants ranges here 800 species (Szafer 1959). Species of very different life requirements appear here frequently side by side, e. g. xerothermic species next to umbriphilous and hydrophilous species. This characteristic aspect of the physiographical conditions of the Cracow-Wieluń Highland, and probably karst terrains in general, was observed not only by botanists (e. g. Pawłowski, 1924; Szafer, 1959), but also by zoologists (e. g. Poliński, 1928).

The differentiation of habitats expresses itself also in abundance of plant associations. Medwecka-Kornaś and Kornaś (1963) distinguished in the area of the Ojców National Park as many as 28 associations. The most important amongst forest associations are here: mixed acidophilous forest *(Pino-Quercetum)*, mixed deciduous forest *(Tilio-Carpinetum)*, Carpathian beech *(Fagetum carpaticum)*; of the brushwood associations: xerothermic hazel brushwood *(Corylo-Peucedanetum cervariae)*. Small rocks are generally covered by mossy associations *(Ctenidietalia)* or grassland *(Festucetum pallentis)*. Of the meadow associations, the most acreage is covered by the fresh meadow *(Arrhenatheretum elatioris)* and pasture *(Lolio-Cynosuretum)*.

The localization of the different associations in the area is, as already mentioned, distinctly dependent on the relief. And so, the plateau is overgrown by mixed acidophilous forest which succession presents itself in three variants, — with dominant pine, fir, or beech. The variant with beech occurs on outcrops of limestone and on the rims of the valleys, i. e. in places of shallowest soil. The distribution of other variants depends on moisture, or results from human

activity. On northerly exposed valley slopes develop beech stands, and at the foot of rocks maple stands *(Phyllitido-Aceretum)* are in evidence. Otherwise exposed slopes are generally grown over by mixed deciduous forest; only in especially warm southerly exposed places, in shallow soil in the neighbourhood of rocks and debris cones, grows xerothermic brushwood. The valley bottoms, significantly changes by human activity, are covered by meadows; fragments of riverside vegetation of the *Alno-Padion* alliance survived only right next to the streams. Saxicolous grassland covers the steep walls of cliffs; on warmest and driest slopes the variant with cheese rennet; on less insolated walls prevails the variant richer in mosses. Deforested southerly exposed slopes are covered by *Origano-Brachypodietum*, which however in some places (e. g. on small rocks and near the Ciemna cave) is certainly a natural association. Shaded and moist rocks in forests are covered by mosses. Other communities occupy smaller areas. Of the natural associations, a small stand of elm forest *(Ficario-Ulmetum)* in Pieskowa Skała, as well as a small stand of steppe grassland *(Koelerio-Festucetum sulcatae)* on slightly inclined rock shelves in Grodzisko must be mentioned here. The scree association *Phegopteridetum Robertianae* grows on deforested debris cones at the base of the rocky walls of valleys, while poor pastures of the *Nardo-Callunetea* order cover deforested valley slopes of other than a southern exposition, and of a rather deeper soil layer.

The presently observed pattern of plant associations developed not only as a result of natural physiographical conditions, but also as a result of long-lasting human activity. First traces of cultivation date from the Neolithic Age. Fortified castles and concentrating around them rural and trade villages existed in the Prądnik valley in the early Middle Ages. Ojców was a busy and fashionable health resort at the end of the 19th and beginning of the 20th century. Also presently, this area is densely enough inhabited. Human influence, besides introduction of synanthropic species, is most significantly marked in the destruction of forests. Forests which covered the valley bottoms were probably very early annihilated; their places were taken by the existing now meadows. Some stands of forest on the plateau were probably also a long time ago destroyed and brought under cultivation. But the most vigorous extermination began at the end of the 19th century. The Ojców forests were then nearly completely felled, and only in most inaccessible places remained small stands. The later conducted afforestations account for the presently observed great share of pine in the present stands. Also in the 30-ties of our century, great cuts were conducted. So now, many sites previously occupied by forest, are covered by other types of vegetation, and forests are mainly represented by young tree-stands.

However, even in spite of human interference, many parts of the forest preserved to a high degree their primary character and belong to the most beautiful on the Cracow-Wieluń Highland. Numerous associations not connected with the forest, especially those of saxicolous grassland, are undoubtly primary formations.

III. INVESTIGATION METHOD

Springtails were collected using all methods applied in fauna investigations of this group (STACH, 1955). It was possible to obtain especially extensive material thanks to using the TULLGREN's apparatus (RAJSKI, 1961). Despite the fact that I collected samples of very different size, which is justified by the character of this paper closely related to fauna; the collected material permits certain conclusions concerning frequency of occurrence of certain species in their habitats (constancy), as well as their relative abundance (dominance). Thus, I was also able to clear the terminology used in connection with occurrence of individual species. And so, a species occurs in a habitat very frequently, if it was found in 75 %, or more, of samples from this habitat; frequently, at an amount of 50—74 %; seldom, 25—49 %; very seldom: less than 25 %. I denominate the relative abundance (dominance) of a species by the following terms: A species occurs in a certain habitat very numerously if its dominance exceeds 10 %; numerously if it ranges 5—9 %; not numerously by 1—4 %; and singly at less than 1 %.

A terminological clearance (distinction) of this kind was possible only for the species collected by TULLGREN's apparatus. For species obtained by other methods, I use sometimes the term „common“ as well as others, without any closer distinction.

As one of the aims of this paper was a description of relations between the springtail fauna and plant associations, the problem of distinction of springtail communities, connected with individual habitats, presented itself. As a main criterion, I assumed the existence of characteristic species (see FRANZ, 1950). By these species I mean such species, which occur in a certain habitat significantly more frequently than in others. So a habitat which has its own, different from others, group of characteristic species; is a separate, according to springtail fauna, habitat.

The material basically used in this paper includes about 300 collected by different methods samples, and more than 140 samples obtained by the use of TULLGREN's apparatus. This amounts to more than 97 000 specimens. In it, I found 157 springtail species, 20 of which are new to the fauna of Poland.

Of the 122 species mentioned for the Cracow-Wieluń Highland (STACH, 1964), I had no opportunity to find 26 in the area of Ojców. However, they were mentioned from areas of slightly different physiographical conditions, or they were found in synanthropic habitats.

The systematic division and denomination are as a rule adopted from STACH's catalogue (1964). The distribution of certain species more interesting from the zoogeographical viewpoint is discussed in the chapter which deals with such matters.

IV. SYSTEMATIC SPECIFICATION

(Reasons for determination are given in brackets after the denomination of the species. * = species new to the fauna of Poland).

1. *Podura aquatica* LINNAEUS, 1758. (*Podura aquatica*: GISIN, 1960).

Does not occur in the Ojców National Park, but I collected it in numbers on the plateau and on the surface of small ponds near farms.

2. *Hypogastrura (Hypogastrura) socialis* UZEL, 1891. (*Neogastrura socialis*: STACH, 1949 a).

Artificial spruce stand; on the snow; 2—3 specimens per m^2.

3. *Hypogastrura (Hypogastrura) assimilis* (KRAUSBAUER, 1898). (*Neogastrura assimilis*: STACH, 1949 a; *Hypogastrura assimilis*: GISIN, 1960).

1 specimen on a stone in a spring.

4. *Hypogastrura (Hypogastrura) vernalis* (CARL, 1901). (*Neogastrura vernalis*: STACH, 1949 a; *Hypogastrura vernalis*: DA GAMA, 1964).

Very frequent and very numerous in xerothermic saxicolous grassland; very seldom and only singly in other habitats. This species is mentioned in the literature existing up to now as hydrophilous (e. g. STACH, 1949 a; GISIN, 1960; DA GAMA, 1964; and others), what however, at least for some areas of Europe, seems not to be correct (see also below).

5. *Hypogastrura (Hypogastrura) crassaeogranulata* (STACH, 1949) (*Neogastrura crassaeogranulata*: STACH, 1949 a) (Pl. XVII, 1—4).

Very frequent or frequent and numerous in umbriphilous saxicolous associations (*Ctenidietalia* and *Festucetum pallentis neckeretosum*). Also common on shaded and moist rock walls. This species is divided into several sub-species; the Ojców population shows most likeness to s-sp. *dobsinensis* STACH, 1949 from Slovakia.

6. *Hypogastrura (Hypogastrura) aequipilosa* (STACH, 1949) (*Neogastrura aequipilosa*: STACH, 1949 a). (Pl. XVII, 5—6).

Under the bark of conifers; also in the litter of *Ficario-Ulmetum* and *Fagetum carpaticum*.

7. *Hypogastrura (Hypogastrura) viatica* (TULLBERG, 1872). (*Neogastrura viatica*: STACH, 1949 a).

I collected this species already outside of the Ojców National Park, in Skała, on the surface of puddles in the road. In Central and Southern Poland, this species seems to be connected with synanthropic habitats (which has been ascertained by my own observations near Poznań and Częstochowa).

*8. *Hypogastrura (Hypogastrura) sahlbergi* (REUTER, 1895). (*Hypogastrura sahlbergi*: GISIN, 1960). (Pl. XVII, 7—8).

1 specimen in the soil of a meadow (*Lolio-Cynosuretum*).

9. *Hypogastrura (Ceratophysella) denticulata* (BAGNALL, 1941). (*Hypogastrura denticulata*: GISIN, 1960).

Frequent or very frequent, but singly in the litter of various forest and brushwood associations. In other habitats very seldom. Also on mushrooms. This species is, as it seems, very widely distributed, but only very recently

accurately distinguished. From Poland, up to now, reported only at Wolin (SZEPTYCKI, 1964), but certainly most of the data concerning *H. (C) armata* (NIC.) are to be applied to this species.

10. *Hypogastrura (Ceratophysella) luteospina* (STACH, 1949). (*Ceratophysella luteospina*: STACH, 1949 a).

Frequent in *Corylo-Peucedanetum*; seldom in *Tilio-Carpinetum*. In other habitats very seldom. Only singly. Also on mushrooms.

11. *Hypogastrura (Ceratophysella) armata* (NICOLET, 1841). (*Hypogastrura armata*: GISIN, 1960). (Pl. XVIII, 1).

5 specimens in dry saxicolous grassland with pine and oak. The species was only recently distinguished with accuracy; most of the earlier data apply probably to *H. (C.) denticulata*.

12. *Hypogastrura (Ceratophysella) sigillata* (UZEL, 1891). (*Hypogastrura sigillata*: GISIN, 1960).

3 specimens: *Fagetum carpaticum* and *Pino-Quercetum* with fir.

*13. *Hypogastrura (Ceratophysella) engadinensis* GISIN, 1949. (*Hypogastrura engadinensis*: GISIN, 1960). (Pl. XVIII, 2).

1 specimen in the soil of a poor pasture (ass. *Agrostis vulgaris*).

14. *Schoettella ununguiculata* (TULLBERG, 1869). (*Schoettella ununguiculata*: STACH, 1949 a).

Seldom, but sometimes very numerous in saxicolous and xerothermic grassland; also single specimens from the litter of riverside brushwood, and from under a stone in the ruins of the Korzkiew Castle.

15. *Schoettella inermis* (TULLBERG, 1871). (*Beckerellodes inermis*: STACH; 1949 a).

Very seldom, but mostly very numerous in xerothermic grassland; singly also in *Ctenidietalia* and in riverside brushwood.

16. *Mesachorutes ojcoviensis* STACH, 1919. (*Mesogastrura ojcoviensis*: STACH, 1949 a).

Does not occur in the area of the Ojców National Park; I collected it only in the position described long ago (DEMEL, 1918; STACH, 1919; STACH, 1949 a) in the Nietoperzowa cave in Jerzmanowice.

17. *Xenylla maritima* TULLBERG, 1869. (*Xenylla maritima*: STACH, 1949 a).

Under the bark of conifers; not too common. 1 specimen also in xerothermic grassland.

18. *Xenylla brevicauda* TULLBERG, 1869. (*Xenylla brevicauda*: STACH, 1949 a; DA GAMA, 1964).

Very seldom, in various habitats.

19. *Xenylla boerneri* AXELSON, 1905. (*Xenylla boerneri*: STACH, 1949 a).

Very frequent and numerous, or very numerous in umbriphilous moss associations. In other associations seldom, or very seldom and singly. 2 specimens also under the bark of fir.

20. *Willemia anophthalma* BÖRNER, 1901. (*Willemia anophthalma*: HÜTHER, 1962).

Frequent or very frequent in the litter of *Pino-Quercetum*. In other habitats seldom, or very seldom. Always singly. Also in detritus in the Cracow cave.

21. *Willemia aspinata* STACH, 1949. (*Willemia aspinata*: HÜTHER, 1962).

Very seldom and singly in the litter of *Pino-Quercetum*; 1 specimen also in *Fagetum carpaticum*.

It seems that the occurrence of both these species is connected with the presence of conifers, and with the chemical composition of the litter.

*22. *Willemia scandinavica* STACH, 1949. (*Willemia scandinavica*: HÜTHER, 1962). (Pl. XVIII, 3—4).

3 specimens in litter of *Tilio-Carpinetum* and *Fagetum carpaticum*; from under the snow.

23. *Brachystomella parvula* (SCHÄFFER, 1896). (*Brachystomella parvula*: STACH, 1949 a).

Very frequent and numerous in the soil of meadow associations; singly specimens also in *Pino-Quercetum* with pine, and in *Ctenidietalia*.

24. *Friesea mirabilis* (TULLBERG, 1871). (*Friesea mirabilis*: STACH, 1949 a).

Meadows: very frequent, numerous; *Pino-Quercetum* with fir, *P. Q.* with pine, *Fagetum carpaticum*, *Ctenidietalia*: frequent, not numerous, or singly. In other associations seldom, or very seldom.

25. *Friesea claviseta* AXELSON, 1900. (*Friesea claviseta*: STACH, 1949 a).

Under the bark of conifers; also in single samples: *Ctenidietalia*, *Festucetum pallentis neckeretosum*, and *Koelerio-Festucetum sulcatae*.

It is possible, that in the material from Ojców occurs also *Friesea sublimis* MACNAMARA, 1921; GISIN, 1960. To ascertain this however, further studies on variability of both mentioned species are imperative.

26. *Odontella lamellifera* (AXELSON, 1903). (*Odontella lamellifera*: STACH, 1949 a).

Very seldom in various deciduous forests.

27. *Odontella pseudolamellifera* STACH, 1949. (*Odontella pseudolamellifera*: STACH, 1949 a).

Tilio-Carpinetum, *Phyllitido-Aceretum*, and riverside brushwood; very seldom.

28. *Xenyllodes armatus* AXELSON, 1903. (*Xenyllodes armatus*: STACH, 1949 a).

Tilio-Carpinetum, *Fagetum carpaticum*: very seldom.

*29. *Microgastrura duodecimoculata* STACH, 1922. (*Microgastrura duodecimoculata*: GISIN, 1960). (Pl. XVIII, 5—6).

Corylo-Peucedanetum, *Tilio-Carpinetum*: very seldom and singly.

30. *Pseudachorutes (Pseudachorutes) dubius* KRAUSBAUER, 1898. (*Pseudachorutes dubius*: STACH, 1949 b).

Fagetum carpaticum: frequent; other forest associations: seldom. Always singly.

31. *Pseudachorutes (Pseudachorutes) corticicolus* (SCHÄFFER, 1896). (*Pseudachorutes corticicolus*: STACH, 1949 b).

Under the bark of various trees. Also very seldom and singly in the soil of various forest associations and umbriphilous moss associations.

*32. *Pseudachorutes (Pseudachorutes) parvulus* Börner, 1901. (*Pseudachorutes parvulus*: da Gama, 1964). (Pl. XVIII, 7—9).

Tilio-Carpinetum, *Corylo-Peucedanetum*: frequent; other forest associations and *Ctenidietalia*: seldom, or very seldom. Always singly.

Specimens from Ojców have chaetotaxy identical with the described for *Ps. parvulus* Börner (da Gama, 1964), but their sensory papilla at the tip of the antennae are as a rule trilobed what brings them also nearer to *Ps. subcrassus* Tullberg, 1871.

33. *Pseudachorutes (Pseudachorutella) asigillatus* Börner, 1901. (*Pseudachorutella asigillata*: Stach, 1949 b).

Tilio-Carpinetum, *Fagetum carpaticum*: very seldom and singly.

34. *Anurida granulata* Agrell, 1943. (*Anurida hexophthalmica*: Stach, 1949 b).

Pino-Quercetum with beech: frequent; other forest associations: seldom, or very seldom and singly.

35. *Micranurida pygmaea* Börner, 1901. (*Micranurida pygmaea*: Stach, 1949 b).

Pino-Querceta and *Fagetum carpaticum*: very frequent and not numerous; other associations: seldom, or very seldom and singly. In the material from Ojców two coloured forms appear: a white one, and a grey-blue one. However I could not find any significant morphological or ecological differences between the two.

36. *Neanura (Neanura) muscorum* (Templeton, 1835). (*Biloba muscorum*: Stach, 1951; *Neanura muscorum*: da Gama, 1964).

Pino-Quercetum with pine: seldom; *Tilio-Carpinetum*, *Pino-Quercetum* with beech, *Ctenidietalia*, meadows: very seldom. Always singly. Also under pieces of wood in various forests.

37. *Neanura (Neanura) parva* (Stach, 1951). (*Biloba parva*: Stach, 1951). (Pl. XIX, 1—3).

Pino-Quercetum with pine: very frequent; other forest associations and *Ctenidietalia*: frequent. In other habitats very seldom. Always singly.

In many specimens from the Ojców area only 4 setea are present on the dorsoexternal tubercles of the mesothorax, but amongst them occur also forms with 1 or 2 setae on the dorsoexternal tubercles of the head. The remaining details of chaetotaxy tally with the description of *N. parva*.

38. *Neanura (Thaumanura) carolii* (Stach, 1920). (*Thaumanura carolii*: Stach, 1951).

More than 10 specimens under pieces of wood in *Fagetum carpaticum* and *Phyllitido-Aceretum*, 1 specimen in the litter of *Pino-Quercetum* with fir.

The occurrence of this species in the area of Ojców seems to be restricted to a small area which includes the northern slopes of the Chełmowa Góra Mtn., and the lower part of the Jamka gorge.

39. *Neanura (Lathriopyga) conjuncta* (Stach, 1926). (*Lathriopyga conjuncta*: Stach, 1951; *Neanura conjuncta*: da Gama, 1964).

Tilio-Carpinetum, *Fagetum carpaticum*, and *Ctenidietalia*: very seldom and singly.

*40. *Neanura (Lathriopyga) phlegraea* CAROLI, 1910. (*Neanura phlegraea*: DA GAMA, 1964). (Pl. XIX, 4—8).

Pino-Quercetum with fir and *Fagetum carpaticum*: frequent; in other habitats seldom, or very seldom. Always singly.

41. *Tetrodontophora bielanensis* (WAGA, 1842). (*Tetrodontophora bielanensis*: STACH, 1954).

Forest associations: frequent, or very frequent; numerous, or not numerous. In other associations only very seldom and singly. Also common in forests on decaying wood, on mushrooms, under stones, and the like.

It is possible to encounter this species in autumn in various habitats quite untypical for it, e. g. in cultivated fields, or in xerothermic grassland. It seems that the species shows during this season especially great activity.

42. *Onychiurus absoloni* (BÖRNER, 1901). (*Onychiurus affinis*: STACH, 1954).

Pino-Quercetum with fir, and *P. Q.* with pine: very frequent; other forest associations: seldom, or very seldom. Not numerous, or singly. Also under pieces of wood and under the bark of pine.

43. *Onychiurus sibiricus* (TULLBERG, 1876). (*Onychiurus sibiricus*: GISIN, 1960).

Seldom, or very seldom and singly in forest associations.

44. *Onychiurus armatus* (TULLBERG, 1869). (*Onychiurus armatus*: GISIN, 1960).

In all habitats very frequent, except saxicolous grassland, where frequent. Numerous, or not numerous. Common also under stones, under decaying wood, and in caves.

*45. *Onychiurus illaboratus* GISIN, 1952. (*Onychiurus illaboratus*: GISIN, 1960).

3 specimens; *Pino-Quercetum* with fir.

46. *Onychiurus subuliginatus* GISIN, 1956. (*Onychiurus subuliginatus*: GISIN, 1960).

In various habitats; very seldom and singly.

*47. *Onychiurus latus* GISIN, 1956. (*Onychiurus latus*: GISIN, 1960).

Fagetum carpaticum, *Pino-Quercetum* with beech, *P. Q.* with pine: frequent; in other habitats seldom, or very seldom. Also under pieces of wood and in caves.

*48. *Onychiurus procampatus* GISIN, 1956. (*Onychiurus procampatus*: GISIN, 1960).

Fagetum carpaticum, *Pino-Quercetum* with beech: frequent; *Tilio-Carpinetum*, *Corylo-Peucedanetum*: seldom; *Ctenidietalia*, xerothermic grassland: very seldom. Other features as the last species.

In this paper I have not dealt with the problem of systematic values of species of the *Onychiurus armatus* group, which were distinguished by GISIN.

I only would like to stress here, that three distinguished in the discussed area most common species i. e. *O. armatus* s. str., *O. latus*, and *O. procampatus*, differ quite distinctly in their ecology (Tabl. II). *O. armatus* s. str. is a decidedly eurytopic species, whereas the remaining two are connected with the litter of forest with a great share of beeches. Relatively frequently occur asymmetrical forms which cannot be included in any of these species. Possibly, we are dealing here with the „sibiling species" of the Anglo-Saxon authors, which are ecologically different and already genetically isolated, but still not very distinctly separated morphologically.

It is also of some interest that in the very abundant material of the *armatus*-group which I investigated, I found only very closely related forms, which differed in number of pseudocelli only in an insignificant degree. And so, *O. subuliginatus* is of pseudocellar formula 34/023/33343, — *O. armatus* and *O. illaboratus*: 33/023/33343, — the remaining: 33/022/33343. On the other hand, there are completely no forms with a greater number of pseudocelli on the abdomen which are widely spread in Western Europe.

*49. *Onychiurus zschokkei* HANDSCHIN, 1919. (*Onychiurus zschokkei*: GISIN, 1957). (Pl. XX, 1—2).

More than 10 specimens: *Ctenidietalia*, 1 specimen under a stone at the brink of some hornbeam shrubs and a meadow.

50. *Onychiurus granulosus* STACH, 1930. (*Onychiurus granulosus*: STACH, 1954).

Forest associations and shrubs: very frequent and numerous, or very numerous. *Ctenidietalia*: frequent and singly; in other associations: very seldom and singly. Also common in forests under stones, under pieces of wood, and in caves.

51. *Onychiurus fimetarius* (LINNAEUS, 1758). (*Onychiurus fimetarius*: STACH, 1954).

Riverside brushwood and *Tilio-Carpinetum*: seldom; other forest associations: very seldom. Singly.

Of the forms of the *O. fimetarius* group, distinguished by GISIN I found in the area of Ojców: *O. insubrarius* GISIN, 1952; a form nearing *O. silvarius* GISIN, 1952, but without ventral organs in males; as well as a form of pseudocellular formula 32/033/33343 (*Onychiurus fimetarius* sensu DENIS: GISIN, 1960). The small amount of material makes it however impossible to state if those forms do not differ also ecologically.

52. *Tullbergia (Tullbergia) krausbaueri* (BÖRNER, 1901). (*Mesaphorura krausbaueri*: STACH, 1954).

In all habitats very frequent or frequent, and numerous or not numerous.

53. *Tullbergia (Tullbergia) callipygos* BÖRNER, 1903. (*Tullbergia callipygos*: GISIN, 1960). (Pl. XX, 3).

Pino-Querceta: very frequent, not numerous or singly; other forest associations: very seldom and singly.

It seems that occurrence of this species, analogically to two species of the

Willemia genus (see above), is dependent on the presence of conifers in a concrete plot.

From Poland this species was reported by STRENZKE (1949) from near Koszalin.

54. *Tullbergia (Metaphorura) bipartita* HANDSCHIN, 1920. (*Metaphorura bipartita*: STACH, 1954).

Saxicolous and xerothermic grassland, *Festucetum pallentis neckeretosum*: frequent; *Tilio-Carpinetum*, *Ctenidietalia*, meadows: very seldom. Singly or not numerous. Also under stones in dry places.

55. *Tullbergia (Stenaphorura) quadrispina* (BÖRNER, 1901). (*Stenaphorura quadrispina*: STACH, 1954).

Meadows: seldom and not numerous; *Tilio-Carpinetum*, *Ctenidietalia*, saxicolous and xerothermic grassland: very seldom and signly.

56. *Tetracanthella arctica* CASSAGNAU, 1959. (*Tetracanthella arctica*: CASSAGNAU, 1959; *Tetracanthella wahlgreni*: STACH, 1947). (Pl. XX, 4).

Ctenidietalia, *Festucetum pallentis neckeretosum*, saxicolous and xerothermic grassland: very seldom and not numerous, or singly.

57. *Anurophorus (Anurophorus) laricis* NICOLET, 1842. (*Anurophorus laricis*: STACH, 1947).

Pino-Quercetum with pine: very frequent and very numerous; in the remaining *Pino-Querceta*: frequent and not numerous; *Fagetum carpaticum*: very seldom and singly.

58. *Anurophorus (Pseudanurophorus) binoculatus* (KSENEMAN, 1934). *Pseudanurophorus binoculatus*: STACH, 1947).

4 specimens in the litter of *Fagetum carpaticum*, from under the snow.

59. *Folsomides (Folsomides) parvulus* STACH, 1922. (*Folsomides parvus*: STACH, 1947).

Saxicolous and xerothermic grassland: seldom; *Festucetum pallentis neckeretosum*, meadows: very seldom. Singly.

60. *Folsomides (Subisotoma) angularis* (AXELSON, 1905). (*Subisotoma angularis*: STACH, 1947).

Saxicolous and xerothermic grassland: frequent and not numerous; *Festucetum pallentis neckeretosum* and riverside brushwood: very seldom and singly.

61. *Folsomides (Subisotoma) pusillus* (SCHÄFFER, 1900). (*Subisotoma pusilla*: STACH, 1947). (Pl. XX, 5—6).

Tilio-Carpinetum, *Fagetum carpaticum*, *Ctenidietalia*: very frequent and numerous, or very numerous; *Pino-Quercetum* with beech, *P. Q.* with fir, *Corylo-Peucedanetum*: frequent and not numerous, *Pino-Quercetum* with pine, saxicolous and xerothermic grassland, meadows: very seldom and singly.

62. *Isotomodes productus* (AXELSON, 1906). (*Isotomodes productus*: DA GAMA, 1963).

Festucetum pallentis neckeretosum, saxicolous and xerothermic grassland, meadows: very seldom and singly.

*63. *Isotomodes sexsetosus* DA GAMA, 1963. (*Isotomodes sexsetosus*: DA GAMA, 1963). (Pl. XX, 7).

4 specimens: *Phyllitido-Aceretum*, *Fagetum carpaticum*, and meadow *(Lolio-Cynosuretum)*.

64. *Folsomia candida* WILLEM, 1902. (*Folsomia candida*: STACH, 1947).

Meadows: seldom and singly. Reported by STACH (1947), also from the Nietoperzowa cave in Jerzmanowice.

*65. *Folsomia listeri* BAGNALL, 1939. (*Folsomia listeri*: GISIN, 1960). (Pl. XX, 8).

Fagetum carpaticum, meadows: very seldom and singly. However common in detritus from caves.

66. *Folsomia fimetaria* (LINNAEUS, 1758). (*Folsomia fimetaria*: GISIN, 1960). (Pl. XX, 9).

Very seldom and singly in various associations.

67. *Folsomia quadrioculata* (TULLBERG, 1871). (*Folsomia quadrioculata*: STACH, 1947).

Forest associations, umbriphilous moss associations: very frequent and numerous, or very numerous; meadows: frequent and not numerous; saxicolous and xerothermic grassland: seldom and not numerous.

In the denomination „*Folsomia quadrioculata*" I include probably two species, namely *F. quadrioculata* s. str., and *F. nana* GISIN, 1957. The species, which are very much alike, differ in length of the setae in the afterpart of the abdomen (the length of mucro in relation to the longest setae is in *F. quadrioculata* 1:3,5—5, but in *F. nana* 1:2,3—3). On the other hand, I found so many transitory forms in my material that an accurate distinction is, for the moment at least, impossible (see also RUSEK, 1963; PETERSEN, 1965).

68. *Folsomia multiseta* STACH, 1947. (*Folsomia multiseta*: STACH, 1947).

Forest associations and brushwood: very frequent or frequent, and very numerous or numerous; *Ctenidietalia*: frequent and singly.

69. *Proisotoma* sp.

2 specimens in the litter of *Fagetum carpaticum*. Probably species nova.

70. *Proisotoma minima* (ABSOLON, 1901). (*Proisotoma minima*: STACH, 1947).

Meadows: seldom and singly.

71. *Hydroisotoma schaefferi* (KRAUSBAUER, 1898). (*Hydroisotoma schaefferi*: STACH, 1947).

On stones in springs, also on those dripping with water; on shaded rocks, and on tree stems.

72. *Appendisotoma* sp.

1 specimen (juv.) on snow.

73. *Isotomina thermophila* (AXELSON, 1900). (*Isotomina thermophila*: STACH, 1947).

More than 10 specimens in the soil of a meadow *(Arrhenatheretum elatioris)*.

74. *Isotomina bipunctata* (Axelson, 1903). (*Isotoma bipunctata*: Stach, 1947).

Ctenidietalia, *Festucetum pallentis neckeretosum*, and in the scree association with *Phegopteris Robertiana*: very seldom and singly.

75. *Isotomiella minor* (Schäffer, 1896). (*Isotomiella minor*: Stach, 1947).

Tilio-Carpinetum, *Fagetum carpaticum*, *Pino-Querceta*: very frequent and numerous, or not numerous; *Corylo-Peucedanetum*: frequent and not numerous; *Ctenidietalia*: frequent and singly; *Festucetum pallentis neckeretosum* and meadows: seldom and singly; saxicolous and xerothermic grassland: very seldom and singly.

76. *Pseudisotoma sensibilis* (Tullberg, 1876). (*Pseudisotoma sensibilis*: Stach, 1947).

On growths on wood stems, under the bark, and so on, common; also, though very seldom in moss associations on rocks, and in the litter of *Corylo-Peucedanetum*.

77. *Vertagopus arborea* (Linnaeus, 1758). (*Vertagopus arborea*: Stach, 1947).

4 specimens, *Ctenidietalia*.

78. *Vertagopus cinerea* (Nicolet, 1841). (*Vertagopus cinerea*: Stach, 1947).

Common under the bark of trees, more seldom under pieces of wood and in the litter.

79. *Isotoma olivacea* Tullberg, 1871. (*Isotoma olivacea*: Stach, 1947).

Tilio-Carpinetum, *Fagetum carpaticum*, *Pino-Quercetum* with beech, *Ctenidietalia*, meadows: seldom, or very seldom and singly. Probably a cosmopolitan species.

In my material, besides the typical form, occurs also the form known under the denomination „*Spinisotoma pectinata*". Therefore, it doesn't develop only as stated by Stach (1961) amongst young specimens of *Isotoma fennica* Reuter, 1895, which it was impossible to find in the area of Ojców, but also amongst young specimens of *I. olivacea*.

80. *Isotoma notabilis* Schäffer, 1896. (*Isotoma notabilis*: Stach, 1947).

Saxicolous and xerothermic grassland: seldom and singly; *Festucetum pallentis neckeretosum*: very seldom and singly; in the remaining habitats: very frequent and not numerous.

81. *Isotoma albella* Packard, 1873. (*Isotoma albella*: Stach, 1947).

Under the bark of conifers.

82. *Isotoma viridis* Bourlet, 1839. (*Isotoma viridis*: Stach, 1947).

Meadows: very frequent and not numerous; other habitats: very seldom and singly. Common also under stones in moist places, on moist rock walls, a. s. o. Also on snow, and on the banks of springs and streams.

83. *Isotoma hiemalis* Schött, 1893. (*Isotoma hiemalis*: Stach, 1947).

Pino-Quercetum with pine: several specimens on snow.

84. *Isotoma violacea* Tullberg, 1876. (*Isotoma violacea*: Stach, 1947).

Tilio-Carpinetum, *Fagetum carpaticum*, *Pino-Querceta*, *Ctenidietalia*: very seldom and singly.

85. *Isotoma intermedia* Schött, 1902. (*Isotoma intermedia*: Stach, 1947).

Old fallow, several specimens on snow.

86. *Isotomurus palustris* (Müller, 1776). (*Isotomurus palustris*: Stach, 1947). (Pl. XXI, 1—3).

Meadows: frequent and not numerous; *Ctenidietalia*: very frequent and singly. Common also on banks of springs and streams.

The species is probably cosmopolitan, but merits revision. Yosii (1963) found that a number of long known coloured forms of *I. palustris* deserve the rank of independent species. In my material occur: *f. balteata*, *f. bimaculata*, and *f. fucata*. They don't show however any ecological differences. Therefore, in spite of certain morphological differences between them (especially so in structure of the margin of the labrum), the too uncomplete material makes it impossible for me to decide definitely in this matter.

87. *Oncopodura crassicornis* Schoebotham, 1911. (*Oncopodura crassicornis*: Gisin, 1960).

1 specimen under a stone in riverside brushwood.

88. *Cyphoderus albinus* Nicolet, 1842. (*Cyphoderus albinus*: Gisin, 1960).

Common in ant hills under stones in dry and warm places.

89. *Tomocerus (Tomocerus) minor* (Lubbock, 1862). (*Tomocerus minor*: Gisin, 1960).

Ctenidietalia: very frequent and singly; other associations: very seldom and singly, or not numerous. Common also under pieces of wood, and under stones in moister habitats.

90. *Tomocerus (Tomocerus) vulgaris* (Tullberg, 1871). (*Tomocerus vulgaris*: Gisin, 1960).

Very seldom and singly in various associations. Also analogous to the lastly mentioned species, but significantly more seldom.

91. *Tomocerus (Tomocerus) minutus* Tullberg, 1876. (*Tomocerus minutus*: Gisin, 1961 a). (Pl. XXI, 4—6).

Occurs analogous to the lastly mentioned species. Gisin (1961 a) assumes, that all Central European data concerning *T. minutus* are to be applied to the *T. mixtus* Gisin, 1961 described by him. My specimens however correspond rather to the description of *T. minutus*.

92. *Tomocerus (Pogonognathellus) longicornis* (Müller, 1776). (*Tomocerus longicornis*: Gisin, 1960).

Very seldom and singly in various habitats.

93. *Tomocerus (Pogonognathellus) flavescens* (Tullberg, 1871). (*Tomocerus flavescens*: Gisin, 1960).

Very common in all investigated habitats with exception of exceedingly dry ones.

94. *Orchesella flavescens* (Bourlet, 1839). (*Orchesella flavescens*: Stach, 1960).

Very common under stones, pieces of wood, a. s. o., as well as on plants on meadows, and in the ground flora of various forest associations and brushwood.

95. *Orchesella spectabilis* TULLBERG, 1871. (*Orchesella spectabilis*: STACH, 1960).

Not too common on plants and under stones in dry and warm habitats.

96. *Orchesella xerothermica* STACH, 1960. (*Orchesella xerothermica*: STACH, 1960).

Several specimens under stones: *Cerasus fruticosa* (PALL.) brushwood, *Corylo-Peucedanetum*, and an old clear cut forest area.

97. *Orchesella multifasciata* STSCHERBAKOW, 1898. (*Orchesella multifasciata*: STACH, 1960).

Xerothermic grassland, *Corylo-Peucedanetum*, *Festucetum pallentis neckeretosum*: very seldom and singly.

98. *Orchesella bifasciata* (BOURLET, 1839). (*Orchesella bifasciata*: STACH, 1960).

Saxicolous moss associations: very frequent and numerous; saxicolous and xerothermic grassland, *Corylo-Peucedanetum*: seldom and singly; forest associations: very seldom and singly. Also on shaded rock walls and on tree stems.

99. *Orchesella alticola* UZEL, 1891. (*Orchesella alticola*: STACH, 1960).

Quite common, but only in entrances to caves, and in other shaded and cool parts of rock walls.

100. *Orchesella* sp.

Ctenidietalia: seldom and singly; probably species nova.

101. *Heteromurus nitidus* (TEMPLETON, 1835). (*Heteromurus nitidus*: GISIN, 1960).

Various habitats: very seldom and singly. Also under stones and the like in various habitats, as well as in caves.

102. *Entomobrya nivalis* (LINNAEUS, 1758). (*Entomobrya nivalis*: STACH, 1963).

Very common in various habitats.

103. *Entomobrya multifasciata* TULLBERG, 1871. (*Entomobrya multifasciata*: STACH, 1963).

Very seldom, though sometimes also numerous in saxicolous and xerothermic grassland.

104. *Entomobrya lanuginosa* (NICOLET, 1841). (*Entomobrya lanuginosa*: STACH, 1963).

On plants in dry and warm habitats.

105. *Entomobrya marginata* (TULLBERG, 1871). (*Entomobrya marginata*: STACH, 1963).

Saxicolous and xerothermic grassland: seldom and not numerous; also under the bark of trees.

106. *Entomobrya arborea* (TULLBERG, 1871). (*Entomobrya arborea*: STACH, 1963).

On tree branches and under their bark.

107. *Entomobrya corticalis* (NICOLET, 1841). (*Entomobrya corticalis*: STACH, 1963).

Ctenidietalia: seldom and singly; *Tilio-Carpinetum*, *Pino-Querceta*: very seldom and singly. Common under the bark and on stems of various trees; much more seldom on plants.

108. *Entomobrya quinquelineata* BÖRNER, 1901. (*Entomobrya quinquelineata*: STACH, 1963).

In xerothermic grassland and on plants in dry and warm habitats.

109. *Entomobrya muscorum* (NICOLET, 1841). (*Entomobrya muscorum*: STACH, 1963).

Common in the ground flora of shaded forests; also under pieces of wood, on mushrooms, etc.

110. *Entomobrya dorsalis* UZEL, 1891. (*Entomobrya dorsalis*: STACH, 1963).

Common on tree stems, especially beeches; much more seldom under stones, on plants in various habitats, etc.

111. *Entomobrya superba* (REUTER, 1876). (*Entomobrya superba*: STACH, 1963).

Very seldom and singly in xerothermic grassland; more numerous only in two places (Grodzisko and Grębielice) which include old fallows with great share of xerothermic vegetation.

112. *Sinella myrmecophila* (REUTER, 1886). (*Entomobryoides myrmecophilus*: STACH, 1963).

Common in ant hills.

113. *Willowsia buski* (LUBBOCK, 1870). (*Willowsia buski*: GISIN, 1960).

Pino-Quercetum with beech: very frequent; *Tilio-Carpinetum*, saxicolous moss associations, saxicolous and xerothermic grassland: frequent; other habitats: seldom, or very seldom. Singly. Also on plants and dry rock walls.

114. *Willowsia nigromaculata* (LUBBOCK, 1873). (*Willowsia nigromaculata*: GISIN, 1960).

Saxicolous and xerothermic grassland: very seldom, though sometimes very numerous.

115. *Lepidocyrtus paradoxus* UZEL, 1891. (*Lepidocyrtus paradoxus*: GISIN, 1964 a).

Common on plants and under stones in various habitats.

116. *Lepidocyrtus curvicollis* BOURLET, 1839. (*Lepidocyrtus curvicollis* GISIN, 1964 b).

Several specimens on dry but shaded rock in entrances to caves.

*117. *Lepidocyrtus serbicus* DENIS, 1933. (*Lepidocyrtus serbicus*: GISIN, 1965).

Meadows: very frequent and not numerous; forest associations: very seldom and singly. Also on rock walls and under the bark of trees.

*118. *Lepidocyrtus lignorum* (FABRICIUS, 1793). (*Lepidocyrtus lignorum*: GISIN, 1964 b).

Ctenidietalia, *Pino-Quercetum* with fir: very frequent and not numerous, or singly; *Corylo-Peucedanetum*: frequent and numerous; other associations: seldom, or very seldom and singly. Common also in various habitats under pieces of wood, etc., as well as on plants.

This species has been only recently distinguished, it seems however that most of the concerning *L. lanuginosus* data are to be applied here.

119. *Lepidocyrtus violaceus* (GEOFFROY, 1762). (*Lepidocyrtus violaceus*: GISIN, 1964 a).

Ctenidietalia: very frequent and not numerous; *Festucetum pallentis neckeretosum*: frequent and very numerous. Only very seldom and singly in other associations. Species only recently distinguished; old data merit revision.

120. *Lepidocyrtus ruber* SCHÖTT, 1902. (*Lepidocyrtus ruber*: STACH, 1955).

Meadows: very frequent and very numerous; other associations: wery seldom and singly. Common also on meadow plants.

121. *Pseudosinella wahlgreni* (BÖRNER, 1907). (*Pseudosinella wahlgreni*: GISIN, 1960).

Tilio-Carpinetum, *Pino-Querceta*: frequent; other associations: seldom, or very seldom. Singly. Also under pieces of wood and the like in forests.

*122. *Pseudosinella octopunctata* BÖRNER, 1901. (*Pseudosinella octopunctata*: GISIN, 1960). (Pl. XXI, 7—8).

Saxicolous and xerothermic grassland: frequent; *Festucetum pallentis neckeretosum*: very seldom. Singly.

123. *Pseudosinella alba* (PACKARD, 1873). (*Pseudosinella alba*: GISIN, 1960).

Meadows, saxicolous and xerothermic grassland: very seldom and singly. Also on pieces of wood in very moist riverside brushwood.

124. *Pseudosinella immaculata* (LIE-PETTERSEN, 1896). (*Pseudosinella immaculata*: GISIN, 1960). (Pl. XXI, 9).

2 specimens in meadow soil *(Arrhenatheretum elatioris)*, and in a cave.

*125. *Neelus minutus* FOLSOM, 1901. (*Neelus minutus*: GISIN, 1960). (Pl. XXI, 10—11).

Fagetum carpaticum, *Ctenidietalia*, meadows: very seldom and singly.

126. *Megalothorax minimus* WILLEM, 1900. (*Megalothorax minimus*: STACH, 1957).

Forest associations, *Ctenidietalia*, meadows: very seldom and singly.

*127. *Megalothorax incertus* BÖRNER, 1903. (*Neelus incertus*: GISIN, 1960). (Pl. XXI, 12—14).

Ctenidietalia: very seldom and singly.

DA GAMA (1964) considers this species only as a variety of the lastly mentioned one, what however in view of differences in their ecology seems not to be right.

128. *Sminthurides malmgreni* (TULLBERG, 1876). (*Sminthurides malmgreni*: STACH, 1956).

Several specimens on muddy banks of a stream and in springs.

129. *Sminthurides schoetti* AXELSON, 1903. (*Sminthurides schoetti*: STACH, 1956).

Ctenidietalia, *Cerassus fruticosa* shrubs, meadows: very seldom and singly.

130. *Sphaeridia pumilis* (KRAUSBAUER, 1898). (*Sphaeridia pumilis*: STACH, 1956).

Meadow: very frequent and numerous; *Pino-Quercetum* with fir: frequent and singly; the remaining *Pino-Querceta*, saxicolous moss associations, saxicolous and xerothermic grassland: seldom and singly; *Tilio-Carpinetum*, *Fagetum carpaticum*: very seldom and singly.

131. *Arrhopalites coecus* (TULLBERG, 1871). (*Arrhopalites coecus*: STACH, 1956).

1 specimen in the soil of a poor pasture (ass. *Agrostis vulgaris*).

132. *Arrhopalites pygmaeus* (WANKEL, 1861). (*Arrhopalites pygmaeus*: STACH, 1956).

Common in caves.

*133. *Arrhopalites sericus* GISIN, 1947. (*Arrhopalites sericus*: GISIN, 1960). (Fig. 2, A—C).

Ctenidietalia: frequent; other associations: seldom, or very seldom. Singly.

*134. *Arrhopalites gisini* NOSEK, 1960. (*Arrhopalites gisini*: NOSEK, 1960). (Fig. 2, D—F).

Very seldom and singly in various associations.

135. *Sminthurinus aureus* (LUBBOCK, 1862). (*Sminthurinus aureus*: STACH, 1956). (Pl. XXII, 1—2).

Very seldom and singly in various associations.

136. *Sminthurinus elegans* (FITCH, 1863). (*Sminthurinus elegans*: STACH, 1956).

Tilio-Carpinetum, *Ctenidietalia*, meadows, xerothermic grassland: very seldom and singly.

137. *Sminthurinus niger* (LUBBOCK, 1868). (*Sminthurinus niger*: STACH, 1956). (Pl. XXII, 5).

Tilio-Carpinetum, *Pino-Quercetum* with pine, *Ctenidietalia*: very seldom and singly. Also under the bark and in miscellaneous growth on tree stems.

*138. *Sminthurinus flammeolus* GISIN, 1957. (*Sminthurinus flammeolus*: GISIN, 1960). (Pl. XXII, 3—4).

Saxicolous grassland, — in winter.

139. *Bourletiella arvalis* (FITCH, 1863). (*Bourletiella arvalis*: STACH: 1956).

1 specimen in the soil of a meadow *(Lolio-Cynosuretum)*.

140. *Bourletiella viridescens* STACH, 1920. (*Bourletiella viridescens*: GISIN, 1960). (Pl. XXII, 6).

Several specimens on meadow plants.

141. *Deuterosminthurus repandus* (ÅGREN, 1903). (*Deuterosminthurus repandus*: STACH, 1956).

Very common on plants, especially so in xerothermic habitats.

142. *Deuterosminthurus bicinctus* (KOCH, 1840). (*Deuterosminthurus bicinctus*: STACH, 1956).

Common on plants, especially so in the ground flora of various forest as-

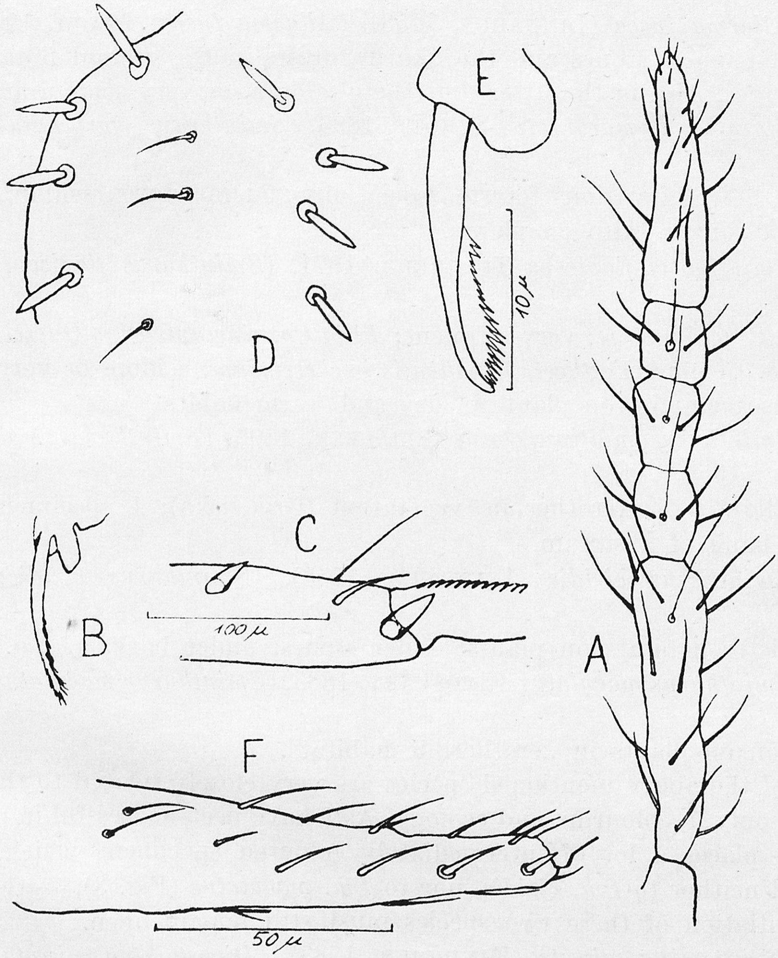


Fig. 2. A—C *Arrhopalites sericus* Gis; A: Fourth antennal segment (enlargment as C), B: Subanal appendage (enl. as C), C: Distal part of the dens. D—F *Arrhopalites gisini* Nosek; D: Chaetotaxy of the upper part of the head (enl. as F), E: Subanal appendage, F: Chaetotaxy of the dens.

sociations. Also in the litter of various forests, but there only very seldom and singly.

143. *Heterosminthurus linnaniemii* (Stach, 1920). (*Heterosminthurus linnaniemii*: Stach, 1956).

On plants in various habitats, but significantly more seldom than the afore mentioned species.

144. *Sphyrotheca lubbocki* (Tullberg, 1872). (*Sphyrotheca lubbocki*: Stach, 1956).

Pino-Querceta, saxicolous moss associations: very frequent and numerous, or not numerous; in the remaining associations with exception of meadows: frequent and not numerous. Also under stones and on tree stems.

145. *Allacma fusca* (LINNAEUS, 1758). (*Allacma fusca*: STACH, 1956).

Common under stones and the like in forests in the ground flora, and on stems of trees. Also in the litter, but there seldom, or very seldom and singly.

146. *Sminthurus marginatus* SCHÖTT, 1893. (*Sminthurus marginatus*: STACH, 1956).

In the litter of various forest associations and meadows: seldom, or very seldom and singly. Also on plants.

147. *Sminthurus flaviceps* TULLBERG, 1871. (*Sminthurus flaviceps*: STACH, 1956).

Corylo-Peucedanetum: very frequent; *Tilio-Carpinetum*, *Pino-Quercetum* with fir, *P.-Q.* with pine, *Festucetum pallentis neckeretosum*: seldom or very seldom. Singly. Also common on plants in dry and warm habitats.

148. *Sminthurus multipunctatus* SCHÄFFER, 1896. (*Sminthurus multipunctatus*: STACH, 1956).

Old fallow with xerothermic vegetation (Grodzisko); 1 specimen also on a muddy bank of a stream.

149. *Sminthurus viridis* (LINNAEUS, 1758). (*Sminthurus viridis*: STACH, 1956).

In moister habitats on plants, under stones, under bark, a. s. o.

150. *Sminthurus maculatus* TÖMÖSVARY, 1883. (*Sminthurus maculatus*: STACH, 1956).

Common on plants in xerothermic habitats.

Both of the above mentioned species are very closely related to themselves and differ only in colouring and ecology. As I have been successful in collecting in several places a lot of intermediately coloured specimens which may be considered neither to *Sm. viridis*, nor to *Sm. maculatus* (Fig. 3), — the matter of differentiation of these two species must still remain open.

151. *Dicyrtomina minuta* (FABRICIUS, 1783). (*Dicyrtomina minuta*: STACH, 1957).

In moister habitats on plants, under stones, a. s. o.

152. *Dicyrtomina ornata* (NICOLET, 1842). (*Dicyrtomina ornata*: STACH, 1957).

Common in various forest associations under pieces of wood and the like, in the ground flora, and on mushrooms; also in the litter.

153. *Dicyrtoma fusca* (LUCAS, 1849). (*Dicyrtoma fusca*: STACH, 1957).

Under pieces of wood and the like, as well as on plants in moister habitats.

154. *Ptenothrix atra* (LINNAEUS, 1758). (*Ptenothrix atra*: STACH, 1957).

Under pieces of wood and the like, and in the litter of various forests, but significantly more seldom than the afore mentioned species.

155. *Ptenothrix setosa* (KRAUSBAUER, 1898). (*Ptenothrix setosa*: STACH, 1957). (Pl. XXII, 7).

1 specimen in the litter; *Tilio-Carpinetum*.

156. *Ptenothrix leucostrigata* STACH, 1957. (*Ptenothrix leucostrigata*: STACH, 1957).

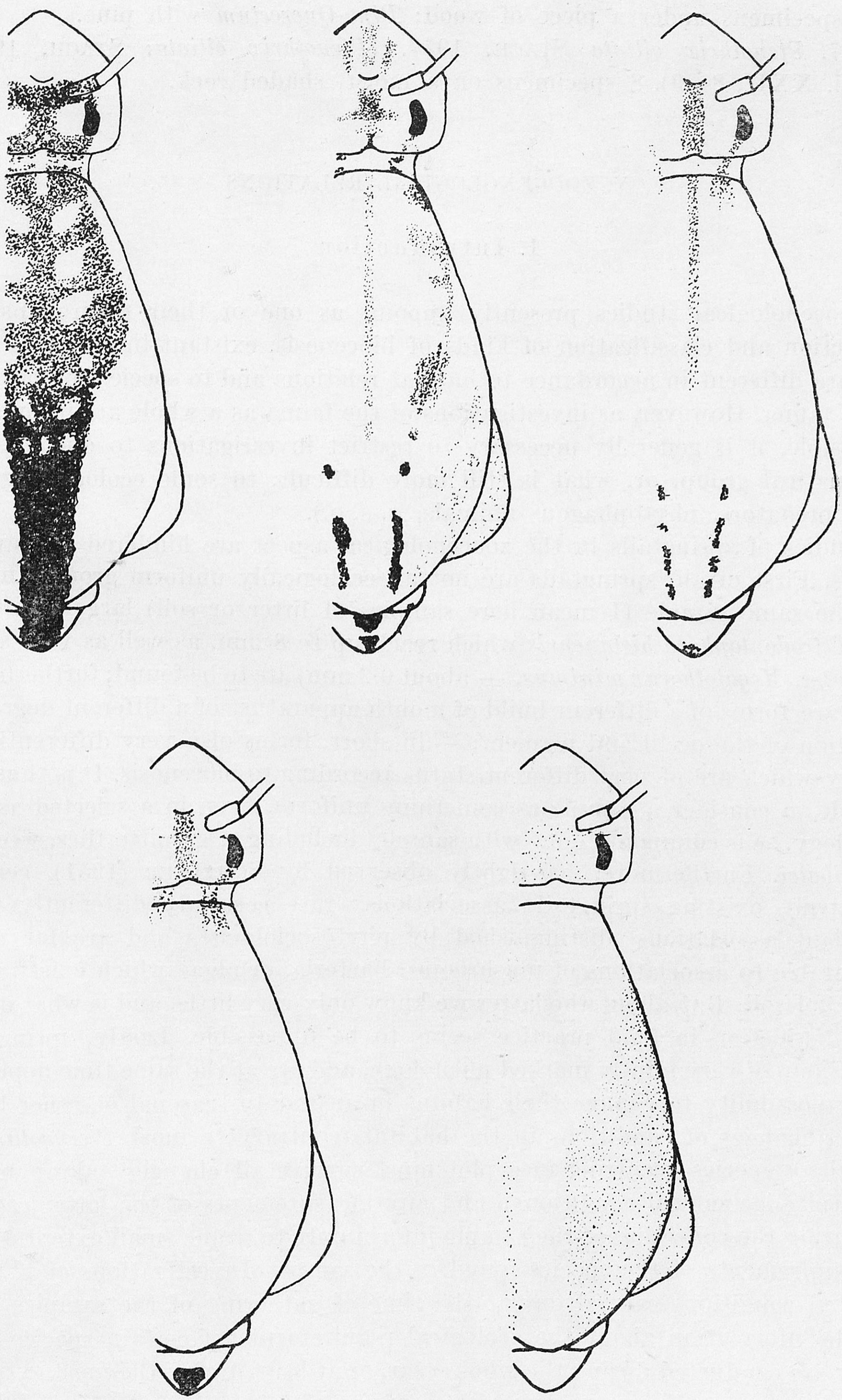


Fig. 3. Coloured forms of *Sminthurus viridis* — *maculatus* complex.

5 specimens under a piece of wood; *Pino-Quercetum* with pine.

157. *Ptenothrix ciliata* STACH, 1957. (*Ptenothrix ciliata*: STACH, 1957). (Pl. XXII, 8—9). 8 specimens on a moist, shaded rock.

V. ZOOCENOLOGICAL RELATIONS

1. Introduction

Zoocenological studies presently appoint as one of their main aims the distinction and classification of kinds of biocenosis, existant in a certain area they are different in accordance to habitat relations and to species composition of the fauna. However, as investigations of the fauna as a whole are in practice impossible, it is generally necessary to restrict investigations to one selected systematical group, or, what is still more difficult, to some ecological group (e. g. predators, phytophagous animals, a. s. o.).

Studies of springtails in the zoocenological aspect are hindered by several factors. First of all, springtails are not an ecologically uniform group. In one and the same sample (I mean here samples of litter or soil) large forms, as e. g. *Tetrodontophora bielanensis* which reach up to 8 mm, as well as very small ones (e. g. *Megalothorax minimus*, — about 0·2 mm) are to be found; furthermore, there are forms of a different build of mouth apparatus, of a different degree of reduction of the ocelli and pigment, — in short, forms of a very differentiated biology which are of very different status according to biocenosis. It is thus impossible to consider a sample as something uniform, even in a selected aspect of biology, as is commonly done with samples including e. g. butterflies, weevils, or *Oribatei*. Furthermore, as rightly observed by SCHALLER (1951), certain objectively existing springtail „associations" rate certainly differently than the plant associations, distinguished by phytosociologists and are far more comparable to associations of mushrooms, bacteria, or algae which exist in the litter and soil. But about the latter we know only very little, and is what more, their distinction in field practice seems to be impossible. Lastly, springtails are a group of very faintly marked phenology, and are at the same time deprived of the possibility to change their habitat in answer to seasonal or other long-termed changes of conditions in the habitat (contrary to most *Pterygota*). As a result, a species occurring in a plot must survive all changes taking effect there (physiochemical conditions), and any measurements of the latter carried out during the collecting of the sample inform only to some small extent about the requirements of the species found in the sample. Investigations of physiochemical conditions carried out at the time of gathering of the samples may provide information about the ecological requirements of certain species only if they are conducted during the whole year, or at least during the most extreme periods. As my studies were directed towards cognition of the fauna composition of the whole area, first of all in the aspect of quality, — and rather not aimed at

relations of quantity, — samples from various places were taken during the whole year. This is also the reason why I did not take measurements of humidity, pH, and others; directing my attention rather towards phytosociological estimation of the investigated plot.

Samples taken for this paper were of very different size which results from their mainly faunistic character; and so the occurrence of a species in some habitat is characterized only by its constancy, i. e. the percentage of samples from said habitat in which the species occurred. I denominate this by the figures 1—4 for the classes: less than 25 %, 25—49 %, 50—75 %, and more than 75 %.

According to the differentiation of life forms in springtails I divided them after GISIN (1943) into three groups, different in biology and morphology. They are:

1. euedaphon — including forms which lead an underground life. Characteristic for these are short limbs and antennae, reduction of ocelli and pigment, as well as certain details in morphology of the sense organs.

2. hemiedaphon — including forms which live on the ground surface. Characteristic for these are longer limbs and antennae, a full (in general) number of ocelli, and more or less developed pigment (in the hemiedaphon group, GISIN distinguishes several sub-groups which are however insignificant in our contemplation).

3. atmobios — includes forms which live on plants. Characteristic for these are long limbs and antennae, and strongly developed pigment.

The division cited here is mainly based on morphology of the individual species, and not on their biology. Thus, during its practical application, certain inconsequences occur. As the morphologically distinguished euedaphon stands in fact for forms which live deeper in the soil, so the difference between hemiedaphon and atmobios is a very unconstant one. Only very few species are for certain to be accounted for as atmobios, and very many forms which morphologically answer to the definition of hemiedaphon occur also on plants. For these reasons I discuss in the chapter which deals with atmobios not only those species which belong to this morphological group, but the whole fauna which appears on plants. Surely simplicity is a favorable feature of GISIN's distinction, which cannot be said about other attempts of classification of this type (e. g. BOCKEMÜHL, 1956).

The material from TULLGREN's apparatus of course includes mainly the two first groups. The frequency of species belonging to them is shown in Table II (euedaphon), and III (hemiedaphon). The Table IV (appendix) includes either species which are so rare that their abundance was impossible to analyze according to zoocenology, or species which belong morphologically distinctly to atmobios and occur commonly on plants, so that finding of those in the litter is to be considered rather as accidental.

Already on hand of inspection of species in the individual samples was it possible to amass in one lot samples originating from xerothermic and saxi-

colous grassland (*Festucetum pallentis sempervivetosum*, *Koelerio-Festucetum sulcatae*, and certain plots *Origano-Brachypodietum*), and also samples from various meadow associations which cover the valley bottoms (*Arrhenatheretum elatioris*, *Lolio-Cynosuretum*, fragments of communities of the *Calthion* order, and others).

Euedaphon — Table II

	X.	Fp.	Ct.	CP.	TC.	Fc.	PF.	PP.	PA.	Md.
Onychiurus armatus	3	4	4	4	4	4	4	4	4	4
Tullbergia krausbaueri	3	4	4	4	3	4	4	4	4	4
Folsomides parvulus	2	1	—	—	—	—	—	—	—	1
Tullbergia bipartita	3	3	1	—	1	—	—	—	—	1
Isotomina bipunctata	—	1	1	—	—	—	—	—	—	—
Arrhopalites sericus	—	2	3	—	1	—	—	—	—	—
Onychiurus granulosus	1	1	3	4	4	4	4	4	4	—
Isotomiella minor	1	2	3	3	4	4	4	4	4	2
Micranurida pygmaea	1	1	2	2	3	4	4	4	4	2
Onychiurus sibiricus	—	—	—	2	2	2	2	1	—	—
Onychiurus procampatus	1	—	1	2	2	3	3	—	—	—
Anurida granulata	—	—	1	—	1	1	3	1	2	—
Onychiurus latus	—	—	—	—	1	3	3	3	2	1
Onychiurus absoloni	—	—	—	1	—	2	3	4	4	—
Willemia anophthalma	—	—	—	1	1	2	3	4	2	—
Tullbergia callipygos	—	—	—	1	1	1	4	4	4	—
Willemia aspinata	—	—	—	—	—	1	1	1	1	—
Sphaeridia pumilis	2	2	2	—	1	1	2	2	3	4
Tullbergia quadrispina	1	—	1	—	—	1	—	—	—	2
Proisotoma minima	—	—	—	—	—	—	—	—	—	2
Folsomia candida	—	—	—	—	—	—	—	—	—	2

Abbreviations: X. — Saxicolous and xerothermic grassland, Fp. — *Festucetum pallentis neckeretosum*, Ct. — *Ctenidietalia*, CP. — *Corylo-Peucedanetum cervariae*, TC. — *Tilio-Carpinetum*, Fc. — *Fagetum carpaticum*, PF. — *Pino-Quercetum* with beech, PP. — *Pino-Quercetum* with pine, PA. — *Pino-Quercetum* with fir, Md. — Meadows.

Besides a number of rarer species, not only in the group of euedaphon, but also in hemiedaphon (Table I and II), it is possible to discern 5 groups of species in the attached tables. The first of them includes eurytopic species, i. e. more or less frequent in all plant associations; the second includes species of a distinct preference for xerothermic and saxicolous grassland; the then following are species of umbriphilous saxicolous moss associations; then the forest species; and finally meadow species. In the range of forest species which belong to the euedaphon, one may distinguish three sub-groups, namely: species which are frequent in all types of forest, species which are connected with deciduous forests, and species which are connected with coniferous forests

Table III

Hemiedaphon
(Abbreviations as in Table II).

	X.	Fp.	Ct.	CP.	TC.	Fc.	PF.	PP.	PA.	Md.
Folsomia quadrioculata	2	4	4	4	4	4	4	4	4	3
Isotoma notabilis	2	1	4	3	4	4	4	4	4	4
Lepidocyrtus lignorum	2	2	4	3	2	2	1	2	4	2
Willowsia buski	3	3	3	2	3	2	4	2	1	2
Entomobrya multifasciata	1	—	—	—	—	—	—	—	—	—
Schoettella ununguiculata	2	—	—	—	—	—	—	—	—	—
Folsomides angularis	3	—	—	—	—	—	—	—	—	—
Willowsia nigromaculata	2	—	—	—	—	—	—	—	—	—
Pseudosinella octopunctata	3	—	—	—	—	—	—	—	—	—
Entomobrya marginata	2	—	—	—	—	1	—	—	—	—
Hypogastrura vernalis	4	—	—	2	1	—	—	—	—	—
Orchesella multifasciata	1	1	—	—	—	—	—	—	—	—
Tetracanthelia arctica	2	1	1	—	—	—	—	—	—	—
Pseudisotoma sensibilis	—	2	1	1	—	—	—	—	—	—
Orchesella bifasciata	2	4	4	2	—	—	—	1	—	—
Xenylla boerneri	1	4	4	—	2	1	—	2	1	—
Lepidocyrtus violaceus	1	3	4	—	—	1	—	1	—	—
Hypogastrura crassaegranulata	—	3	4	—	—	—	—	—	—	—
Tomocerus minor	—	1	4	—	1	1	—	—	—	—
Tomocerus flavescens	—	1	4	2	3	2	2	3	2	2
Folsomides pusillus	1	3	4	—	4	4	3	1	3	1
Sphyrotheca lubbocki	3	4	4	3	3	3	4	4	4	—
Pseudosinella wahlgreni	1	1	3	2	3	2	2	3	3	—
Tetrodontophora bielanensis	1	—	2	4	4	4	3	3	4	—
Neanura parva	—	1	3	1	3	2	3	4	3	—
Folsomia multiseta	—	—	3	3	4	4	4	4	4	—
Pseudachorutes dubius	—	—	1	1	2	3	1	1	1	—
Hypogastrura denticulata	—	1	1	1	4	3	4	3	3	—
Pseudachorutes parvulus	—	—	2	3	3	2	1	1	2	—
Neanura phlegraea	1	2	1	2	1	3	1	1	3	—
Isotoma violacea	—	—	2	—	1	1	1	—	2	—
Hypogastrura luteospina	—	—	1	3	2	1	—	—	—	—
Anurophorus laricis	—	—	1	—	—	1	3	4	3	—
Isotoma olivacea	—	—	1	—	1	2	2	—	—	2
Dicyrtomina ornata	—	—	1	—	2	1	—	1	1	—
Neanura muscorum	—	—	1	—	1	—	1	2	—	1
Sminthurus marginatus	—	—	—	—	1	1	1	1	2	1
Friesea mirabilis	—	2	3	1	2	3	1	3	3	4
Lepidocyrtus ruber	1	—	—	—	1	—	—	—	—	4
Lepidocyrtus serbicus	—	—	—	—	1	1	—	—	—	4
Brachystomella parvula	—	—	—	—	—	—	—	1	—	4
Isotoma viridis	1	—	1	1	—	—	—	—	—	4
Isotomurus palustris	—	—	1	—	—	—	—	—	—	3

The last two sub-groups in the range of hemiedaphon are represented only by single species, namely by those connected with deciduous forests *Hypogastrura luteospina*, and by those connected with coniferous forests *Anurophorus laricis*.

The position of the *Festucetum pallentis neckeretosum* fauna emerges distinctly on hand of the mentioned tables. This is, in spite of the presence of certain xerothermic elements, a kind of fauna which is typical for umbriphilous moss associations. The data on hand also do not permit a distinction as a different fauna of the fauna of the individual forest associations and thermophilous brushwood. The differences in the fauna of various forest types and also brushwood are much less significant than the features of likeness existing between them.

In conclusion, on hand of abundance of species in the individual habitats (constancy), one may distinguish in the area of Ojców 4 main types of springtail fauna, namely: the fauna of xerothermic and saxicolous grassland, of umbriphilous saxicolous moss associations, of forests (which occurs also in thermophilous brushwood), and the fauna of meadows. I mean here the fauna of a certain habitat, and not the community or synusium of springtails in that habitat, as in the composition of every distinguished fauna are at least two synusia, according to Gisin's (1943) meaning (i. e. euedaphon, and hemiedaphon) included, and anyhow; the fauna composition of every community includes several groups of species of different ecological requirements.

After discussion of the four main fauna types, I shall discuss the fauna of certain habitats which are not included in these Tables, and the atmobios.

2. Fauna of saxicolous and xerothermic grassland

Saxicolous and xerothermic grassland includes three plant associations: *Festucetum pallentis sempervivetosum*, *Koelerio-Festucetum sulcatae*, and certain plots of *Origano-Brachypodietum*. These associations, composed generally of xerophilous and thermophilous plants, develop on more or less inclined rock walls of southern exposure. Soil of the rendzina type of alkaline reaction is characteristic. Strong insolation and shallowness of the soil are the reasons for which these habitats are, except during rain periods, strongly dried out. Extreme, according to moisture and thermical relations, conditions result in a relatively poor but exceedingly characteristic fauna.

The species occurring in the associations discussed here are shown in the first column (X) of the Tables II—IV. Dominating are: *Hypogastrura vernalis* — 37 %, and *Tullbergia krausbaueri* — 9 %. Also a very high degree of dominance in the individual samples is reached by *Schoettella inermis*, *Willowsia nigromaculata*, and *Folsomides angularis*. The maximum number of species in a sample is 21, mean about 12. The following species are characteristic: *Hypogastrura vernalis*, *Schoettella ununguiculata*, *Schoettella inermis*, *Tullbergia bipartita*, *Folsomides parvulus*, *Folsomides angularis*, *Entomobrya multifasciata*, *Willowsia nigromaculata*, *Pseudosinella octopunctata*.

Table IV

Appendix
(Abbreviations as in Table II).

	X.	Fp.	Ct.	CP.	TC.	Fc.	PF.	PP.	PA.	Md.
Hypogastrura aequipilosa	—	—	—	—	—	1	—	—	—	—
„ *sahlbergi*	—	—	—	—	—	—	—	—	—	1
„ *sigillata*	—	—	—	—	—	1	—	—	1	—
Schoettella inermis	1	—	1	—	—	—	—	—	—	—
Xenylla brevicauda	1	—	1	—	1	—	1	—	1	—
„ *maritima*	1	—	—	—	—	—	—	—	—	—
Willemia scandinavica	—	—	—	—	1	1	—	—	—	—
Neanura conjuncta	—	—	1	—	1	1	—	—	—	—
„ *carolii*	—	—	—	—	—	1	—	—	1	—
Friesea claviseta	1	—	1	—	—	—	—	—	—	—
Xenyllodes armatus	—	—	—	—	1	1	—	—	—	—
Odontella lamellifera	—	—	1	—	—	1	—	—	—	—
„ *pseudolamellifera*	—	—	—	—	1	—	—	—	—	—
Microgastrura duodecimoculata	—	—	—	1	1	—	—	—	—	—
Pseudachorutes corticicolus	—	1	1	—	1	—	—	1	—	—
„ *asigillatus*	—	—	—	—	1	1	—	—	—	—
Onychiurus subuliginatus	—	—	—	—	—	1	—	1	1	1
„ *illaboratus*	—	—	—	—	—	—	—	—	1	—
„ *zschokkei*	—	1	1	—	—	—	—	—	—	—
„ *fimetarius*	—	—	—	—	2	—	—	—	—	—
Isotomodes productus	1	1	—	—	—	—	—	—	—	1
„ *sexsetosus*	—	—	—	—	—	1	—	—	—	1
Anurophorus binoculatus	—	—	—	—	—	1	—	—	—	—
Folsomia fimetaria	—	—	—	—	—	—	—	1	1	—
„ *listeri*	—	—	—	—	—	1	—	—	—	1
Isotomina thermophila	—	—	—	—	—	—	—	—	—	1
Vertagopus arborea	—	—	1	—	—	—	—	—	—	—
„ *cinerea*	—	—	—	—	1	—	—	—	—	—
Cyphoderus albinus	1	—	—	—	—	—	—	—	—	—
Tomocerus longicornis	—	—	—	1	—	—	—	1	—	—
„ *minutus*	—	—	1	—	1	1	—	—	—	—
„ *vulgaris*	—	—	1	—	—	—	—	—	2	—
Orchesella flavescens	—	—	1	—	1	1	—	1	1	—
„ *spectabilis*	—	—	—	—	1	—	—	—	—	—
„ *xerothermica*	—	—	—	1	—	—	—	—	—	—
Heteromurus nitidus	—	—	—	—	1	—	—	—	—	1
Entomobrya nivalis	1	1	2	—	—	1	—	1	2	—
„ *corticalis*	—	—	2	—	1	—	—	1	1	—
„ *quinquaelineata*	1	—	—	1	—	—	—	—	—	—
„ *superba*	1	—	—	—	—	—	—	—	—	—
„ *dorsalis*	—	—	—	—	1	—	—	—	—	—
„ *muscorum*	—	—	—	—	1	—	—	—	—	—
Pseudosinella alba	1	—	—	—	—	—	—	—	—	1
“ *immaculata*	—	—	—	—	—	—	—	—	—	1
Megalothorax incertus	—	—	1	—	—	—	—	—	—	—

Table IV (contd.)

	X.	Fp.	Ct.	CP.	TC.	Fc.	PF.	PP.	PA.	Md.
Megalothorax minimus	—	—	1	—	1	1	—	1	2	—
Neelus minutus	—	—	1	—	—	1	—	—	—	1
Sminthurides schoetti	—	—	1	—	—	—	—	—	—	1
Sminthurinus aureus	—	—	1	1	1	—	1	1	1	1
„ *elegans*	1	—	1	—	1	—	—	—	—	1
„ *niger*	—	—	1	—	1	—	—	1	—	—
„ *flammeolus*	1	—	—	—	—	1	—	—	—	—
Arrhopalites gisini	—	1	1	—	—	—	1	1	2	—
Deuterosminthurus repandus	1	—	—	2	1	—	—	—	—	1
„ *bicinctus*	—	—	—	2	1	1	—	—	1	—
Heterosminthurus linnaniemii	—	—	—	—	—	—	—	—	—	1
Bourletiella lutea	—	—	—	—	—	—	—	—	—	1
Allacma fusca	—	—	1	1	2	1	—	1	3	—
Sminthurus maculatus	2	1	—	2	—	—	—	—	—	—
" *flaviceps*	—	1	—	4	1	—	—	2	1	—
„ *viridis*	—	—	—	—	—	—	—	—	—	1
Dicyrtoma fusca	—	—	—	2	1	1	—	—	—	—
Ptenothrix atra	—	—	1	—	—	—	—	—	1	—
„ *setosa*	—	—	—	—	1	—	—	—	—	—

Amongst them, *Hypogastrura vernalis* was frequently considered (e. g. Stach, 1949; Gisin, 1960; Szeptycki, 1964; da Gama, 1964; and others) a hydrophilous species. But Törne's (1958), Hüther's (1961), and Naglitsch's (1962) investigations enable us to state that we are here dealing with a species which is distinctly associated with dry habitats of a high pH. Also *Folsomides angularis* was considered by Stach (1947) to be a species which is associated with moss overgrowing small rocks near water reservoirs. However, except in xerothermic grassland, I could find only one specimen in riverside brushwood in the whole Ojców area.

Schoettella ununguiculata, *Sch. inermis*, *Folsomides parvulus*, *Entomobrya multifasciata*, and *Willowsia nigromaculata* are known as xerophilous species, however, except *Folsomides parvulus* not associated with distinctly xerothermic habitats. They occur in various dry habitats, e. g. in dry litter, under bark, in birds' nests, and so on. It seems interesting that *Schoettella inermis* in areas which are situated farther to the North is a species which is quite closely associated with the litter of pine forests (Agrell, 1941; Szeptycki, 1964), whereas it does not occur in mixed acidophilous forests in the Ojców area, or is very seldom found there. *Entomobrya multifasciata* and *Willowsia nigromaculata* on the other hand, occur in certain areas of their range only synanthropically (see Linnaniemi, 1912; Stach, 1959).

There are no detailed ecological data in literature, except some general statements, relating to *Tullbergia bipartita* and *Pseudosinella octopunctata*.

The differentiation of the fauna of xerothermic and saxicolous grassland, depending on association and concrete plot, is quite significant. The most extreme conditions prevail in *Festucetum pallentis sempervivetosum*, much less extreme in *Origano-Brachypodietum*. By the way, the lastly mentioned association is not uniform its of origin. It includes primary plots (e. g. in a group of rocks near the Ciemna cave), as well as plots which developed relatively late as a result of cutting down of forests.

Samples taken from *Festucetum pallentis sempervivetosum* are very poor in species. Among species without distinct preference to other associations (eurytopic) only *Onychiurus armatus* and *Tullbergia krausbaueri* occur here frequently. The eurytopic species from the hemiedaphon group occur here significantly more seldom than in other associations.

In the typical *Origano-Brachypodietum*, besides xerothermic species, occurs frequently a number of eurytopic species, as well as certain forest species. This is understandable if we consider that *Origano-Brachypodietum* does not occur as a rule at the border of thermophilous brushwood (*Corylo-Peucedanetum*) which already has forest fauna of springtails, but presents also a natural link in succession from saxicolous grassland to thermophilous brushwood (Medwecka-Kornaś and Kornaś, 1963). Lastly, the fauna of plots which developed relatively recently presents a little original mixture of eurytopic and forest species. Species which are characteristic for xerothermic grassland occur here relatively seldom (see below).

Our attention may be directed at the fact of occurrence of such forest species in grassland with pine, as *Anurophorus laricis* and *Tullbergia callipygos*.

There exist also two species which both occur in the fauna of the mentioned grassland and meadows. They are *Isotomodes productus* (grassland, *Festucetum pallentis neckeretosum*, and meadows), and *Pseudosinella alba* (grassland, meadows, and riverside brushwood). It is however possible that in the case of the latter we are dealing with two species up to now undistinguished.

The springtail fauna of saxicolous grassland, except that of certain mountain areas, is very little known in Central Europe. The fauna of the montane saxicolous grassland, as well as the fauna of xerothermic associations which develop on other ground (e. g. Schaller, 1951; Nosek and Ambrož, 1964) is quite different. The most ostentatious difference is probably the lack in those habitats of the *Hypogastrura vernalis* so common and numerous in the Ojców grassland whereas this species occurs undoubtedly in the included in the mentioned papers areas.

The most similar to the grassland fauna described here seems to be the described by Nosek (1957) soil fauna of a xerothermic forest-steppe in the Small Carpathian Mts (= Malé Karpaty). But there also *Hypogastrura vernalis* does not occur too numerously, though the species is frequent. Also comparable with the Ojców grassland fauna is the fauna belonging to the synusium euedaphon *Tullbergia affinis* which is described by Gisin (1943) from dry grassland near Bâsle (if, what is very probable, *Tullbergia affinis* sensu Gisin = *Metaphorura*

bipartita sensu STACH). However, several species which are frequent in this synusium (*Isotomodes productus*, *Folsomia fimetaria*, *F. candida*, *Isotomina bipunctata*, and *Oncopodura crassicornis*) occur in the area of Ojców very seldom or in other habitats. Correlating with the synusium *Tullbergia affinis* is the synusium *Pseudachorutes falteronensis* belonging to the hemiedaphon, which is at all different from the hemiedaphon of the Ojców grasslands.

3. Fauna of umbriphilous saxicolous moss associations

Umbriphilous saxicolous moss associations occupy more or less shaded and moist rock walls, i. e. walls which are surrounded by forest, or of other than southern exposure. They include two plant associations (MEDWECKA-KORNAŚ and KORNAŚ — 1963), i. e. the umbriphilous associations of the *Ctenidietalia* order; mainly the association *Neckera complanata* — *Anemodon viticulosus* (SZAFRAN, 1955), as well as the in less insolated places developing variant of saxicolous grassland *Festucetum pallentis neckeretosum* (acc. to SZAFRAN: ass. *Neckera complanata* — *Anemodon viticulosus*, variant with *Neckera crispa*). Characteristic for those associations is significant moisture; it seems also, that these habitats are quite cold, especially the former one. Influence on springtail fauna have also, besides the already mentioned microclimatic factors, the small amount of decaying organic matter and rot, as well as the large number of mosses. Also the passage of water through certain plots in rainy periods is certainly of some significance. Both of the here discussed associations differ to some extent in living conditions. *Festucetum pallentis neckeretosum* is a bit drier, warmer, and more photophilous than associations of the *Ctenidietalia* order. However, there are no distinctly characteristic species for every one of

Table V

	Fp.	Ct.
Lepidocyrtus violaceus	17%	3%
Onychiurus armatus	13	1
Sphyrotheca lubbocki	8	1
Pseudisotoma sensibilis	6	0.5
Orchesella bifasciata	8	5
Hypogastrura crassaeogranulata	5	3
Folsomia quadrioculata	5	13
Folsomides pusillus	7	31
Xenylla boerneri	6	23
Maximal number of species in one sample	20	30
Mean in one sample approximately	11	26

Abbreviations as in Table II.

these habitats separately, and the large number of those which are characteristic for both of them, compels to consider them simultaneously.

The fauna composition of umbriphilous moss associations is shown in the 2nd (Fp), and 3rd (Ct) column of Tables II to IV. The dominant in both associations species are shown in Table V.

Significantly characteristic for some saxicolous moss associations are the following species: *Xenyıla boerneri*, *Hypogastrura crassaeogranulata*, *Tomocerus minor*, *Orchesella bifasciata*, *Lepidocyrtus violaceus*, *Arrhopalites sericus*.

As it seems, three of the species mentioned here, i. e. *Xenylla boerneri*, *Lepidocyrtus violaceus*, and *Arrhopalites sericus*, find their optimal life conditions in mosses, independently on ground (Agrell, 1941; Gisin, 1943; Strenzke, 1949; Gisin, 1960, 1964 a). The *Hypogastrura crassaeogranulata* lives in various habitats in the high mountains and in caves (but other sub-species); *Tomocerus minor* is a common species in various moist habitats; and finally *Orchesella bifasciata* is a quite eurytopic species (Stach, 1960), though in our area it is a form which is distinctly characteristic for shaded rocks.

Besides the mentioned species, also *Tetracanthella arctica* and *Isotomina bipunctata* deserve special attention. In our area these species are closely connected with the ground, — they are „rock"-species. The former, besides the discussed habitats, occurs in xerothermic grassland, — the latter in fern associations on debris *(Phegopteridetum Robertiani)*.

Differences in localization of both of the associations discussed here cause quite distinct differences in the springtail fauna of these associations. Thus a certain share of xerothermophilous species, as *Pseudosinella alba*, or *Tullbergia bipartita* is marked in the fauna of *Festucetum pallentis neckeretosum*. Also characteristic to some extent for this association is *Pseudisotoma sensibilis*, which otherwise is also common under the bark of various trees. A certain number of forest species occurs here exceedingly more seldom than in *Ctenidietalia*, what is not only a result of microclimatic conditions, but topographically accounted for. And so, *Ctenidietalia* develop generally on rocks which are surrounded by forest, whereas *Festucetum pallentis neckeretosum* grows also on shaded rock walls in deforested areas. In general, this is a habitat which is distinctly poor in comparison with more shaded rocks.

In samples from the *Ctenidietalia* association, besides the species characteristic for saxicolous moss associations already discussed, a number of forest species occur commonly, whereas of the rare species only in this habitat were found: *Onychiurus zschokkei*, *Vertagopus arborea*, *Orchesella* sp. (probably sp. nova), and *Megalothorax incertus*.

A fauna very much like the discussed one occurs also on shaded rock walls which are not overgrown by mosses, but only by various lichens, algae and blue-green algae. Besides the species already discussed, as e. g. *Lepidocyrtus violaceus*, or *Hypogastrura crassaeogranulata* and a number of common hydrophilous forms, special attention be called here to *Orchesella alticola*, which occurs in this habitat commonly, but was not found outside of it. Of the rare forms

I collected in this habitat also *Lepidocyrtus curvicollis*. But this seems to be a species which is in general attached rather to drier habitats, as I collected it only at cave entrances of southern exposition.

Not all plots of saxicolous associations have their typical fauna. This applies mainly to plots of *Marchantia polymorpha* which grow on bases of rocks in most wet places, as well as to moss associations which grow on slightly inclined rock walls in recently deforested areas (e. g. the bottom of the Korytania gorge). These plots represent impoverished forest fauna.

Analogically to the above mentioned habitat, also the fauna of shaded rock walls is only very poorly known in Central Europe. There are however more data available concerning the fauna of mosses growing on trees (Gisin, 1943; Strenzke, 1949; Bödvarsson, 1961), as well as concerning the moss fauna of single stones (Strenzke, 1949; Bödvarsson, 1961). *Xenylla boerneri* occurs frequently and numerously in all these habitats. In the moss fauna of tree stems a bigger share of typical corticophilous species is marked; e. g. *Anurophorus laricis*, or *Entomobrya corticalis*, whereas markedly smaller than in umbriphilous saxicolous moss associations is the share of the belonging forms to the euedaphon.

4. Fauna of forests

Forests and brushwood in the Ojców area are mainly represented by 4 associations: *Corylo-Peucedanetum*, *Tilio-Carpinetum*, *Fagetum carpaticum* (in two variants), and *Pino-Quercetum* (in three variants) with dominating beech, fir, and pine. In spite of the fact that these associations occur in very different sites, different in relation to soil, inclination, exposition, microclimate, and so on, — their fauna is astonishing alike. Distinctly marked is only the difference between deciduous forests, and mixed acidophilous forests, but lack of a group of species which would be distinctly characteristic for the former prevents consideration of it as a different habitat in the aspect of springtail fauna. This is probably caused by the high percentage of deciduous trees in mixed acidophilous forests in the investigated area.

Species which belong to the composition of the forest fauna are presented in 3rd to 9th columns in the Tables II to IV. Dominant species are shown in Table VI.

Characteristic to a high degree for forest fauna are the following species: *Onychiurus granulosus*, *Isotomiella minor*, *Folsomia multiseta*, *Tetrodontophora bielanensis*.

to a low degree: *Lepidocyrtus lignorum*, *Hypogastrura denticulata*, *Pseudosinella wahlgreni*.

These species occur frequently also in *Ctenidietalia*, which seems to show evidence that they are umbriphilous. In literature they are known as occurring in the litter of various forests. The driest and warmest habitat of the associations discussed here is thermophilous brushwood *Corylo-Peucedanetum*. This

Table VI

	CP.	TC.	Fc.	PF.	PA.	PP.
Folsomia quadrioculata	21	30	28	30	35	37
Folsomia multiseta	20	15	21	13	10	5
Onychiurus armatus	3	7	6	5	4	4
Lepidocyrtus lignorum	8	+	0.1	0.1	0.2	0.1
Sphyrotheca lubbocki	7	2	1	2	1	0.5
Tetrodontophora bielanensis	9	8	4	2	5	1
Onychiurus granulosus	5	11	8	12	4	11
Folsomides pusillus	4	7	7	4	5	+
Isotomiella minor	3	3	6	4	4	3
Tullbergia krausbaueri	3	1	2	2	5	6
Anurophorus laricis	—	—	+	1	4	6
Maximal number of species in the sample	28	27	35	27	27	28
Mean number of species in the sample	16	20	21	21	23	23

Abbreviations as in Table II.

association develops often on debris cones of southern exposition. The soil is shallow rendzina which shows as a rule many sceletal parts. Besides species common in other forest types, a number of more thermophilous species occurs here. A relatively frequent occurrence in the litter of to the atmobios belonging species is marked. Thus, very frequent is here *Sminthurus flavescens* (in other habitats rare in the litter, or even very rare, but common on plants), more frequently than in other habitats occurs also *Deuterosminthurus repandus*, and *D. bicinctus*. A certain degree of fidelity for this association is shown by *Hypogastrura luteospina*. Of the remaining thermophilous species, the following species deserve attention: *Microgastrura duodecimoculata*, *Hypogastrura vernalis*, *Entomobrya quinquefasciata*, *Orchesella xerothermica*, and *Sminthurus maculatus*.

Also the fauna of *Cerasus fruticosa* (Pall.) brushwood approaches the fauna of *Corylo-Peucedanetum* very closely. However, here occur additionally the otherwise not found in forest associations, *Orchesella multifasciata*, *Pseudosinella alba* and *Sminthurides schoetti*; as well as the generally rare in forests hydrophilous *Isotoma viridis*.

The variability of the *Sphyrotheca lubbocki* common in various habitats presents itself as interesting. This species generally darkblue with grey is very variable in thermophilous brushwood and constitutes a number of mostly light-coloured forms.

The two remaining deciduous associations, *Tilio-Carpinetum*, and *Fagetum carpaticum* have a very similar fauna. The fauna of *Tilio-Carpinetum* seems to be intermediary between *Corylo-Peucedanetum* and *Fagetum carpaticum* which results of course from the localization of these associations in the area. *Tilio-Carpinetum* frequently occupies sites in the close neighbourhood of the former.

It has no characteristic species of its own, and only *Pseudachorutes parvulus* is to a certain degree characteristic for this association and for *Corylo-Peucedanetum*. *Pseudachorutes dubius* is to a certain extent characteristic for *Fagetum carpaticum*. This association has already an intermediate position between deciduous forests and mixed acidophilous forests. This results probably from the relatively significant share of conifers.

Mixed acidophilous forests *(Pino-Querceta)* occupy generally positions on the plateau. The variant with beech develops on outcrops of limestone on a shallow layer of loess. The remaining variants develop on deeper and more or less podzolic soil. Human interference which is especially marked on the plateau, is doubtless of some importance (planted pinestands and spruce introduced by man).

The main factor which influences springtail fauna is, as it seems, the presence of conifers, and the thus resulting chemical features of the litter.

To a high degree characteristic for coniferous forests are: *Tullbergia callipygos*, *Willemia anophthalma*, *Anurophorus laricis*.

Of the rarer species characteristic to a high degree is probably *Willemia aspinata*. All these species occur also in other associations, but seldom and only then, if in the concrete plot occur conifers. The differentiation of habitats causes, that most xerophilous and thermophilous species occur in the variant with pine and beech, whereas umbriphilous and hydrophilous species occur in the variant with fir.

Besides the above mentioned, three more associations are represented in the forests of Ojców. Thus, there is a very small plot of *Ficario-Ulmetum*, some very destroyed fragments of riverside forests (of the *Alno-Padion* order), and several small maplestands between boulders *(Phyllitido-Aceretum)*. The fauna of these associations does not differ significantly from the forest fauna already described. From the here occurring, and otherwise rare or not occurring in other types, species, deserve our attention: *Hypogastrura aequipilosa* and *Odontella lamellifera* in *Ficario-Ulmetum*; *Hypogastrura crassaeogranulata*, *Neanura conjuncta*, *Pseudachorutes asigillatus*, and *Isotomodes sexsetosus* in *Phyllitido-Aceretum*; *Odontella pseudolamellifera* in *Phyllitido-Aceretum* and in riverside forest; as well as *Folsomides angularis* in riverside forest. All these species however occur in the mentioned associations only singly. Much more numerously than in other forest types, occurs in riverside forest *Tetrodontophora bielanensis*, which reaches in some samples about 40 % of dominance.

The fundamentally forest fauna however does not live only in the actually existing forests. It occurs in places which were deforested during the last several score years. These positions are occupied, depending on ground and exposure, by various associations. Slopes of southern exposure are overgrown by thermophilous and xerophilous grassland; less insolated and warmed slopes of deep soil are covered by fragments of poor pastures (of the *Nardo-Callunetalia* order); and moist gorge bottoms present more or less typical *Lolio-Cynosuretum* associations. Inclined rocks, which were probably initially covered by litter, at

present are overgrown by mosses, and the accumulated debris piles at the foot of rocky valley slopes show fern associations *(Phegopteridetum Robertianae).* In dry and warm grassland, next to eurytopic and forest species, a number of xerothermic species can be found. But *Hypogastrura vernalis* never occurs here numerously. This species occurs at the most in singly specimens. More frequently than in other habitats however, *Isotomodes productus* is found here, and only in such a habitat was I able to secure several specimens of *Hypogastrura armata.* In the soil of poor pastures occur two species which are not found elsewhere, namely *Hypogastrura engadinensis*, and *Arrhopalites coecus.* In plots of small forest meadows, of the meadow species it was possible to find only *Folsomia candida*, and the rare *Pseudosinella alba.* Finally, attention attracts the occurrence, in a fern association on debris, of the exceedingly rare in our terrain, *Isotomina bipunctata.*

In spite of the fact that relatively many investigators have made the fauna of forest soils an object of their studies, our information about this fauna, in relation to Central Europe, is decidedly insufficient, even for a most sketchy attempt of synthesis. From among the data most interesting in comparative aspect, one may mention the Tables of forest fauna of the Eastern Alps, published in FRANZ's paper (1950) (unfortunately without phytosociological data), NOSEK's papers (1957, 1963) concerning the Moravian Beskides and the Small Carpathian Mts., and LOKSA's papers (1956 a, b) of which the first concerns the fauna of *Querceto-Potentilletum albae*, and the second the forest associations of the Bukk Mts. It is also necessary to mention the fragmentary data of KHOLOVA (1958) about the Bohemian Forest, and these of SCHALLER (1949) concerning the vicinity of Vienna. All quoted papers are however concerned mostly with deciduous forests (FRANZ's data dealing with the fauna of coniferous forests are exceedingly fragmentary); the fauna of the coniferous Carpathian forests is nearly completely unknown, while about terrains lying farther northwards not many papers can be mentioned (e. g. STRENZKE's paper (1949) about northern Germany, and AGRELL's (1934) about southern Sweden). Also GISIN (1943) was interested in the fauna of various forest types in the vicinity of Bâsle. It is however relevant, that in view of the development of springtail systematics, even papers written in the 50's are already partly out of date. Furthermore, most of the investigated forest associations are phytosociologically quite different, so that of the data deriving from them, only a small part may have some bearing on our considerations.

In all of the forest types of Central Europe known up to now quite frequently occur eurytopic forms in the soil, and so namely: *Onychiurus armatus*, *Tullbergia krausbaueri*, *Folsomia quadrioculata*, *Isotomiella minor*, *Isotoma notabilis*, and *Lepidocyrtus lanuginosus* (certainly most of the data about the occurrence of the last mentioned species ought to be considered as bearing on the recently distinguished *L. lignorum*) while, as it seems, *Folsomia quadrioculata* occurs more seldom in alpine soil than in other areas. Other distinctly fidele to forest litter species in our terrain are, as it seems, quite restricted in their occurrence

and distinctly rarer in other areas. And so, *Onychiurus granulosus* and *Folsomia multiseta* are reported in forest soil only from the Moravian Beskides, the Small Carpathians, and the Alps; *Tetrodontophora bielanensis* and *Neanura parva* only from the Moravian Beskides and the Small Carpathians; and finally in the matter of distribution of *Hypogastrura denticulata*, it is at present difficult to state something definite. It seems that most former data concerning *Ceratophysella armata* ought to be considered as relevant for *Hypogastrura denticulata*.

In more southernly situated areas significantly more frequent than in Ojców occurrence of *Pseudosinella alba* and *Oncopodura crassicornis* is obvious. In relatively similar to the Ojców beechstands forests (*Fagetum subcarpaticum asperuletosum*, and *F. sc. mercurialetosum*) LOKSA (1956 b) found, besides the two mentioned species, also the comparatively common *Tetracanthella wahlgreni* LINNAN. The distinction of this species may appear a little doubtful, as the revision of the *Tetracanthella* SCHÖTT genus appeared several years after LOKSA's paper. The forest fauna of the vicinity of Bâsle, described by GISIN (1943), shows already serious differences. In this terrain occur, at least in certain forest types, frequently or very frequently, such species which are seldom found in Ojców; e. g. *Onychiurus sibiricus*, *Anurophorus binoculatus*, and *Oncopodura crassicornis*. On the other hand, there do not occur such characteristic for our forests species, as *Tetrodontophora bielanensis*, or *Folsomia multiseta*. Truely enough, the latter was described only in 1947, but this species is so characteristic, that it would have been observed for sure. Furthermore, a number of differences in the species composition of fauna appear of course in both compared areas.

About the fauna of coniferous woods, Carpathian, as well as those of downland character, only very little is known. Coniferous forests which are more northernly situated differ first of all through their lack of southern, or Carpathian species (in the most general meaning); such as *Tetrodontophora bielanensis*, *Folsomia multiseta*, or probably, *Onychiurus granulosus*. What is more, *Neanura muscorum* occurs much more frequently in them, than in our terrain. Frequently occurs also in coniferous forests in the downlands *Schoettella inermis*, a species which is in our terrain mainly restricted to xerothermic habitats.

It seems, in view of what I have said above, that the differentiation of forest springtail fauna is dependent not only on the variety of forest associations, but even more so on macroclimatic and zoogeographically-historical factors. This is illustrated by Table VII which includes the forest associations of Ojców, as well as shaded beech forests of other areas, i. e. FRANZ's Buchenwald (1950) of the North-eastern Alps, LOKSA's *Fagetum subcarpaticum asperuletosum* and *mercurialetosum* (1956) of the Bukk Mts., and NOSEK's *Fagetum* (1963) of the Small Carpathians. The Table contains coefficients of fauna similarity acc. to SZYMKIEWICZ (SZAFER, 1964 p. 347) ($S =$ number of promiscuous species $\times$ $\times$ 100/number of species in the poorer fauna).

The Table was worked out only for most frequent species, i. e. which occur in more than 50 % samples, as in this way being characteristic for a certain

fauna. Comparatively great similarity of fauna types of forests in our terrain, and nearly as great a similarity to the by NOSEK described beech forest fauna is visible. And so it is possible, that in future we may be able to talk about a Carpathian character of the Ojców forest fauna, at present however, too small an amount of material for comparison doesn't permit generalizations of this kind.

Table VII

	1	2	3	4	5	6	7	8	9	10
1	xx	89	89	89	89	89	59	75	50	33
2		xx	89	81	85	80	80	75	50	33
3			xx	87	85	81	90	75	50	33
4				xx	85	68	60	75	50	33
5					xx	81	70	75	50	33
6						xx	80	75	50	33
7							xx	75	50	33
8								xx	100	50
9									xx	50

1—6: Ojców. 1 — *Corylo-Peucedanetum cervariae*, 2 — *Pino-Quercetum* with pine, 3 — *Pino-Quercetum* with fir, 4 — *Pino-Quercetum* with beech, 5 — *Tilio-Carpinetum*, 6 — *Fagetum carpaticum*; 7: the Small Carpathian Mts. (NOSEK, 1963), — *Fagetum*; 8—9: the Bukk Mts. (LOKSA, 1956), 8 — *Fagetum subcarpaticum asperuletosum*, 9 — *F. sc. mercurialetosum*; 10: the North-eastern Alps (FRANZ, 1950), — Buchenwald (Beech forest).

5. Fauna of meadows

Deforested valley bottoms in the Ojców area are covered by mowed meadows and pastures, and in a few very moist places by fragments of communities of tall sedges *(Magnocaricion eleatae)*. Most of this acreage is covered by fresh meadows *(Arrhenatheretum elatioris)* and fertile pastures *(Lolio-Cynosuretum)*, while markedly smaller areas are covered by fragments of *Scheutzerio-Caricetum fuscae* and *Cirsietum rivularis*. All these associations are characterized by comparatively high ground-water level and soil of alluvial origin. It seems however, that basical influence on fauna is exercised by the character of meadow vegetation, as the fauna of all these associations, in spite of a certain differentiation of habitats, is very uniform.

The species composition of fauna is presented in the last column (Md) of Table II to IV. Dominant are: *Lepidocyrtus ruber* — 13 %, *Onychiurus armatus* — 11 %, *Tullbergia krausbaueri* — 10 %, *Friesea mirabilis* — 7 %, *Brachystomella parvula* — 7 %, *Isotoma notabilis* — 6 %, *Sphaeridia pumilis* — 6 %. A relatively high degree of dominance in single samples reach also: *Lepidocyrtus lignorum*, *L. serbicus*, *Isotoma viridis*, and others. The maximal amount of species in one sample comes to 19, mean about 15.

Most characteristic for the fauna of meadows are the following species: *Brachystomella parvula*, *Isotoma viridis*, *Isotomurus palustris*, *Lepidocyrtus ruber*, *Lepidocyrtus serbicus*.

The first three of them represent typical hydrophilous species which are frequently found on the banks of water reservoirs, while the *L. ruber* seem to be distinctly associated with meadow vegetation (see Stach, 1955).

Furthermore, quite a substancial number of species deserve attention, which are in the Ojców area found only in the soil of meadows. Some of them occur in the individual samples quite numerously.

A very similar fauna type occurs also in tall forb associations *(Geranio-Petasitetum)*, whereas small meadows in the forest, though considered by phytosociologists as *Lolio-Cynosuretum*, show only impoverished forest fauna without meadow species.

Interested in meadow fauna were first of all Frenzel (1936) in Lower Silesia, Gisin (1943) in the vicinity of Bâsle, and Strenzke (1949) in Schleswig-Holstein. Comparatively greatest differences with the fauna of the Ojców meadows present the meadows described by Frenzel, probably as a result of a different habitat. He reports qualified as main forms for meadow soil *Hypogastrura armata*, *Friesea mirabilis*, *Onychiurus armatus*, *Tullbergia krausbaueri*, *Folsomia quadrioculata*, *Isotomiella minor*, *Isotoma notabilis*, *I. viridis*, *I. violacea*, and *Lepidocyrtus lanuginosus*. In the Ojców area not only representatives of the sub-genus *Ceratophysella* (one cannot trust the former denominations of this group), as also *Isotoma violacea* occur only very seldom in meadows; rather only accidentally. But in meadows in Lower Silesia neither *Brachystomella parvula*, nor *Isotomurus palustris* were found. The by Gisin for *Arrhenatheretum* (synusium *Tullbergia quadrispina* and *Brachystomella parvula*) described meadow fauna is as a rule very similar to our fauna. It differs however in occurrence of certain probably south-westernly, species which already don't occur in our terrain, as e. g. *Tullbergia crassicuspis*, and *T. tricuspis*. Attention is also called to the fact, that amongst characteristic for the meadow hemiedaphon species, Gisin mentions *Schoettella ununguiculata*, — a species which is in our terrain distinctly xerophilous and thermophilous. Also the fauna described by Strenzke is very similar to ours, and differs only in occurrence of certain rare species unimportant, for the general fauna picture.

Although the meadows which cover the valley bottoms are a doubtless artificial habitat, they show a very specific fauna. This is probably mainly associated with the age of the meadows. The habitat is doubtless very old and exists if not since the Neolithic Age, so at least since the Early Middle Ages (Medwecka-Kornaś and Kornaś, 1963).

The meadow fauna derives generally from the peat bog fauna (Gisin, 1943), or from the fauna of associations which occupy the banks of water reservoirs (as declared by Rajski, 1961, in connection with *Oribatei*). In case of the Prądnik valley doubtless some waterside associations, most probably tall forb brushwood

(Geranio-Petasitetum), are the object of our considerations. It is however imperative to remember, that the meadow fauna developed in climatic conditions which were little different from the now prevailing, which prevents us from naming one concrete association or associations as parental.

6. Other habitats

Besides the above mentioned, also other habitats were investigated, thus namely caves, banks of water reservoirs, and the under the bark of trees occurring fauna.

The cave fauna was investigated quite a long time ago (Demel, 1918), and my studies added here comparatively little, the more so as I restricted myself to several bigger caves in the area of the National Park, namely to the caves in the Jamka gorge (Zbójecka, Piętrowa, Krakowska, and Biała), as well as the Ciemna cave. I may add that the Łokietka cave is destroyed owing to extensive tourist activities, and the Koziarnia cave is inaccessible as a result of conducted there, for the last several years, archeological investigations.

The fauna of the few organic relicts which are found deep in the caves is poor, but exceedingly characteristic. Three species occur here regularly, i. e. *Folsomia listeri*, *Arrhopalites pygmaeus*, and *Heteromurus nitidus* or *Onychiurus armatus*. If fir needles enter the composition of the plant debris, *Willemia anophthalma* occurs also. Of the species mentioned here only *Arrhopalites pygmaeus* is a troglobite species; this species was not found in our terrain outside of caves. It was found however outside of caves in Western Europe (e. g. Cassagnau and Delamare, 1953). *Folsomia listeri* and *Heteromurus nitidus* appear in the Ojców area in various habitats, they are however markedly more frequent and numerous in caves, and so we are compelled to consider them as troglophile species (at least in the discussed area). *Onychiurus armatus* is, as already several times stressed, a distinctly eurytopic form, and *Willemia anophthalma* is a species which is associated with the needle layer of coniferous forests. In the Ojców area, species originating from caves don't differ morphologically from ones found in other habitats. This applies also to *Onychiurus armatus*, which already in the Tatra Mts. constitutes a very distinct cave variety *O. a.* var. *multituberculata* Stach, 1934 (Stach, 1954).

The differentiation of cave fauna is very interesting. Thus, *Heteromurus nitidus* occurs very frequently only in the Ciemna cave; in caves in the Jamka gorge it occurs very seldom, and there I succeeded in finding only one specimen. On the other hand, *Onychiurus armatus* occurs much more frequently and numerously in the caves in the Jamka gorge, than in the Ciemna cave. Of certain importance may be here the surroundings of the caves. In the Jamka gorge caves are surrounded by beeches, whereas the Ciemna cave opens into a group of rocks covered by xerothermic brushwood or grassland. It is also impossible to exclude human activity, as the Ciemna cave several years ago

served as a storing house, whereas the caves in the Jamka gorge, besides tourist traffic, were not disturbed.

In the entrances to the caves in the Jamka gorge, and in the Biała cave also in the soil, accumulate big piles of driven in litter. Their fauna doesn't differ from the fauna of the surrounding beech stands, frequently however, one finds there species which are associated with caves, as the mentioned *Folsomia listeri* and *Arrhopalites pygmaeus*.

Already DEMEL (1918) directed our attention to the fact, that the fauna of the Ojców caves is very young; therefore its small originality in relation to the surrounding habitats. This is mainly caused by the destructive activity of the Pleistocene glaciations which definitely destroyed the primary, tertiary fauna. The only troglobite species in our terrain (I mean here only the area of the National Park, and therefore don't mention *Mesachorutes ojcoviensis* which occurs in the outside of this area situated Nietoperzowa cave), *Arrhopalites pygmaeus* shifted probably also recently to the cave life-course, as in the whole reach of its distribution area, from Spain to Central Europe, specimens from caves seemingly don't show any morphological differences. This is all the more strange, as in caves of Southern and Western Europe, the genus *Arrhopalites* constitutes many endemic cave forms (see GISIN, 1960).

The fauna of banks of water reservoirs. Water reservoirs in the investigated area are represented by numerous springs of the karst outflow kind, streams and millraces, as well as artificial fish ponds. The springtails were collected on the banks, on stones which stood out of the water, and in the moist moss overgrowing the banks along the waterline. The fauna of these habitats is composed of typical hydrophilous species, such as *Isotoma viridis*, *Isotomurus palustris*, or *Tomocerus minor*. Next to them occurs a number of common everywhere found species such as e. g. *Orchesella flavescens*, *Tomocerus flavescens*, and others. Very important is the connection of the fauna of stream banks with the surrounding habitat. In parts of streams which are surrounded by fragments of riverside brushwood occur a substancial number of forest forms, as e. g. *Dicyrtomina ornata*, and others, whereas in parts which flow through meadows, meadow forms, as e. g. *Lepidocyrtus serbicus*, or *L. ruber* are found. In the fauna of mosses overgrowing the banks, besides the already mentioned, occurs a number of species belonging to the euedaphon, as e. g. *Onychiurus armatus*, *Tullbergia krausbaueri*, *Megalothorax minimus*, and others. The typical water-surface species are in our terrain represented only by two species which occur rather seldom anyway. They are *Hydroisotoma schaefferi*, and *Sminthurides malmgreni*. The former occurs on stones in springs, but is also found, though markedly more seldom, on small rocks wet from overflowing water, some distance away from water reservoirs. The latter occurs very seldom in the area of the National Park among plants growing around springs, but is a little more frequent in the Prądnik valley several kilometers below the park border, where numerous pools and puddles appear on the muddy banks of the Prądnik river.

Thus the Ojców fauna of water reservoirs is obviously very strongly impoverished, in relation to the fauna occurring in the downlands. It lacks e. g. a number of common in the lowlands species of the *Sminthurides* genus, or as common water-surface species as *Podura aquatica*, or *Isotomurus ciliatus*. True enough, that these species are to a marked degree associated with stagnant water, but in Ojców they don't find living conditions appropriate for them, neither in fish ponds, nor on the small, overgrown by duckweed, backwaters of the Prądnik river. It may be, that their occurrence is impossible for climatic reasons (water temperature), or for reasons connected with the chemical composition of the water. It seems also that in Ojców don't occur, besides the mentioned *Hydroisotoma schaefferi*, species associated with mountain springs and creeks, such as *Agrenia bidenticulata*, or *Isotomurus palliceps*.

The corticophilous fauna in the Ojców area is represented by typically corticophilous species, as e. g. *Pseudachorutes corticicolus*, *Vertagopus cinerea*, *Pseudisotoma sensibilis*, *Isotoma albella*, and *Entomobrya corticalis*. To these added a number of xerophilous species, such as *Xenylla maritima* (in Ojców more frequent under the bark, than in other habitats), *Entomobrya marginata*, and *Willowsia buski* (rather eurytopic in Ojców). Of the rare species attention deserves *Entomobrya arborea*. Visible is however lack of, or it occurs only very seldom, *Anurophorus laricis*. This species, which is considered a typically corticophilous species, occurs very commonly in our terrain in the litter of mixed acidophilous forests; however I did not succeed in finding it under bark. Most of the species mentioned here occur also in growth on tree stems, but here a number of species which are not closely associated with trees must be added; such as *Orchesella flavescens*, *Tomocerus flavescens*, *Allacma fusca*, *Sphyrotheca lubbocki*, and others. More frequent than in other habitats is in the growth of shaded tree stems *Sminthurinus niger*, whereas on the stems of insolated trees in the forest edge *Entomobrya dorsalis* occurs especially frequently and numerously.

7. The atmobios

In his classification of springtail life-forms Gisin (1943) distinguishes as an individual group the atmobios, — springtails which live on plants. However, besides forms which are distinctly adapted to this life course, also frequently on plants occur such forms, which in relation to morphology would have to be classified rather to the hemiedaphon, and which occur also commonly on the ground or in the litter. Thus, I consider the term „atmobios“ in a rather more extended manner than in its originally intended morphological meaning, as bearing not only on species representing one life form, but all the fauna which is encountered on plants. And so, „atmobios“ in my manner of understanding, corresponds to Agrell's (1941) „Makrophytenfauna“.

The main factor which influences the species composition of the atmobios is doubtless insolation, and connected with it temperature, as well as moisture

conditions. In this way one may distinguish two groups of species, — photophilous, and umbriphilous species.

Furthermore, one distinguishes three sub-groups in the former two groups. The first of them includes photophilous and xerophilous (or thermophilous?) species which are associated with xerothermic vegetation. Here belong: *Sminthurus multipunctatus*, *Entomobrya superba*, *E. lanuginosa*, *Sminthurus maculatus* (maybe only the ecological race *Sm. viridis?*), and *Deuterosminthurus repandus*. It is true that the two latter ones occur also in other habitats, however nowhere as numerously as in xerophilous and thermophilous grassland. Of the rarer species one ought certainly include in this group also *Entomobrya quinquelineata*, and *Orchesella spectabilis*.

The second sub-group included photophilous, but rather euryhygric species. These are species which live in xerothermic grassland, as well as on the vegetation of moist meadows. Here belong *Lepidocyrtus paradoxus*, *Heterosminthurus linnaniemii*, and may be also *Dicyrtoma fusca*.

Finally the third sub-group of photophilous species includes distinctly hydrophilous species which occur on the plants of meadows, here, besides the already mentioned *Lepidocyrtus ruber*, belongs also *Sminthurus viridis*.

The umbriphilous atmobios occurs on plants in the forest ground flora. Here belong first of all *Entomobrya muscorum*, *Deuterosminthurus bicinctus*, and *Sminthurus flaviceps*. Besides them one finds frequently on plants in the ground flora species which are common also in the litter, on tree stems, and so on, as e. g. *Tetrodontophora bielanensis*, *Orchesella flavescens*, *Lepidocyrtus lignorum*, *Allacma fusca*, and others. Differences between the various forest types are quite indistinctly marked. *Sminthurus flaviceps* occurs more frequently in thermophilous brushwood and in warmer plots of *Tilio-Carpinetum*, than in other forest types; *Entomobrya muscorum* is more frequent in cooler and more shaded forests.

Also the influence of insolation is marked, especially in xerothermic plots, in the daily rhythm of the atmobios. For illustration: I collected in the same plot at noon (25 hits with the sampler) 16 specimens belonging to three species, but in the evening 62 specimens of 12 species. I observed the same phenomenon collecting with the sampler on a slope in full sun, and in a fragment which was shaded by a single tree. Most resistant to extreme temperature and heat conditions are *Sminthurus maculatus*, and *Deuterosminthurus repandus*. They are frequently the only species which occur on slopes in full sun.

Discussing the atmobios it is also necessary to mention species which occur on tree branches. This habitat was only very inaccurately investigated in the Ojców area; there are no data available in literature concerning it. Of the rare species occurs here *Entomobrya arborea*. Furthermore, frequent are also *E. nivalis*, and *E. dorsalis*.

We know very little about the springtail fauna occurring on plants, as it caused much lesser interest than the fauna in the soil. Very similar to the in Ojców occurring umbriphilous atmobios is the synusium *Orchesella flavescens*

Gisin (1943) which occurs in the forests near Bâsle. Besides the very rare here *Tomocerus langicornis*, and *Lepidocyrtus curvicollis*, as well as the not occurring in the Ojców area *Deuterosminthurus bilineatus*, it shows no greater differences. This would attest to the fact, that the forest atmobios is in extensive terrains of Europe more or less uniform. Gisin's meadow atmobios (synusium *Sminthurus viridis*) differs already quite seriously, whereas the by Bockemühl (1956) described atmobios of xerothermic sites in the Schwabenland Jura is completely different.

VI. ZOOGEOGRAPHICAL PROBLEMS

1. Introduction

Insufficient cognition of springtail fauna of many terrains, as well as still developing systematics of the group, are responsible that the working on these problems investigators attack zoogeographical matters rather without liking. Moreover the generally wide distribution zones of many species, contribute to the result, that springtails are considered a decidedly uninteresting for the zoogeographer group. On the other hand, it was not considered that they are rather small forms capable to survive unfavorable conditions in very small areas of specific microclimate, thanks to which they are to a high degree independent of the general climate. Furthermore it seems that many species have significantly lesser possibilities of inactive extension than is thought generally, — in one word, that this group may be also very attractive in many aspects for the zoogeographer.

In this chapter I would like to attempt a zoogeographical analysis of the fauna of the investigated area, as well as to present certain hipotheses concerning its history, mainly on hand of analogy in plant geography and of observations of „microtopographical" species distribution in the field. Thanks to great differentiation of relief and microclimates, Ojców is an especially appropriate area for investigations of this kind.

2. Fauna analysis

The springtail fauna of Ojców is relatively rich. I found in this small area 157 species, and when comes the time of a more accurate cognition of the synanthropic and winter fauna, this figure certainly will exceed 170 species. It may be useful to add for comparison that up to now there are reported from the Pienines 75 species, Tatra Mts. — 134, the Western Beskides including the Nowy Targ basin — 151, the Sudetes — 70 (Stach, 1964), from Czarnohora without the families *Lepidocyrtidae* s. Stach, 1955, *Tomoceridae*, *Cyphoderidae*, and *Oncopoduridae*, as well as without the *Sinella* genus — 104 species (Stach, monograph, 1947 etc.), from the Small Carpathian Mts. — 128 (Nosek, 1963), and

from the North-eastern Alps — 236 species (Frantz and Sertl-Butschek, 1954). Differences in the number of species result first of all from the various accuracy of investigations, but also from the different size of the investigated areas. Of the mentioned terrains doubtless the most accurately investigated were the Tatra Mts., Lower Carpathian Mts., and the North-eastern Alps.

I divide the species occurring in the Ojców area into four groups depending on their distribution, not taking into account recently described forms about the distribution of which it is impossible to say something definite. They are:

1. widely distributed species,	107	species	=	appr.	68 %
2. montane species,	10	„	=	„	6 %
3. Boreal-alpine species,	7	„	=	„	4 %
4. southern species,	8	„	=	„	5 %.

It is difficult to comment on the distribution zone of 25 species which constitute about 17 %.

1. Widely distributed species include either cosmopolitan species, or palearctic, holoarctic, and finally widely distributed in Central Europe species. In one word, — species which are of no great value to zoogeographical consideration of the fauna of our terrain. In this group occur however several species which deserve attention. They are species from the lowlands which don't occur in the mountains of Central Europe, or occur there very seldom and only in lower regions. To these seem to belong the following species:

Orchesella multifasciata [1] — known from numerous sites in our lowlands; from Czechoslovakia, Podole, Wołyń, Eastern Austria, Hungary, and the Balkan Peninsula (Fig. 4; 2). An individual sub-species was described from Turkestan (Stach, 1960).

Entomobrya quinquelineata — known from numerous sites in our lowlands, furthermore widely distributed in Western Europe; reported also from North Africa.

Entomobrya superba — distributed from Finland to Southern France and Yugoslavia.

Pseudosinella octopunctata — known all of Europe from Norway to the Balkans and Italy; probably cosmopolitan.

Sminthurus multipunctatus — probably distributed in all of Europe from Scandinavia to Spain.

2. Montane species, — that means species which are more or less widely distributed in the mountains of Central Europe, or even farther, but distinctly associated with mountains. Here belong:

Hypogastrura crassaeogranulata — occurs in its nominate subspecies high in the Tatra Mts., the Caucasus, and in the North-eastern Alps. Other sub-species are known from caves in Slovakia, Frankland, Southern France, and the Pyrenees (for map of distribution see, Marcuzzi, 1963).

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[1] The distribution zones of species are mainly given after Salmon's catalogue (1964).

Hypogastrura luteospina — known from numerous sites in the whole range of the Carpathian Mts., as well as from the North-eastern Alps; also from Yugoslavia, the Italian caves, and the Pyrenees where it constitutes an individual sub-species.

Odontella pseudolamellifera — up to now known from the Nowy Targ basin, several sites in Slovakia, Czarnohora, and Istria (Fig. 5; 3).

Neanura parva — reported from the Małopolska, and the Cracow-Wieluń uplands, the Carpathian Mts., and the North-eastern Alps.

Neanura carolii — known from the whole range of the Carpathian Mts., the North-eastern Alps, and mountains of the Balkan Peninsula. Occurs also in Roztocze and the Sudetes (my own observations), as well as in certain single-certainly relictic sites in Sambia (Fig. 4; 3).

Neanura conjuncta — known from the Małopolska upland, the Carpathian Mts., the Bohemian Forest, the Alps, and the mountains on the Balkan Peninsula. An individual sub-species was described from the Pyrenees.

Tetrodontophora bielanensis — occurs in the whole range of the Carpathian Mts., the Sudetes, and on the mountains of the Balkan Peninsula. In the South of our country it descends in close distribution quite far to the North (detailed distribution map by Dunger, 1961), but single sites along big rivers reach Pomerania (Sartowice, near Świecie; Bielinek n./Odra, near Chojna; — information by Prof. Dr. Rafalski).

Onychiurus zschokkei — up to now known from the Alps, and the Pirin Mts. (Rusek, 1965) (Fig. 5; 2).

Hydroisotoma schaefferi — widely distributed in the mountains of Europe and North America; seems not to occur in Scandinavia.

Orchesella alticola — known from the Tatra Mts., Sudetes and Czarnohora, as well as from several sites in Lower Silesia and the Cracow-Wieluń upland (Szeptycki, 1963). An individual sub-species occurs in the Alps. Data from the British Isles apply to an different species, what I had opportunity to ascertain during my investigation of material from Ireland and Scotland, thanks to the kindness of Dr. P. N. Lawrence of the British Museum.

It is obvious that all these species, except *Onychiurus zschokkei* and the rare *Odontella pseudolamellifera*, occur mostly in the whole range of the Carpathian Mts., and are in general widely distributed in other mountain areas. The lack of montane Tatra- or Alp endemites in our terrain is quite obvious, whereas interesting is the lack of certain Carpathian endemites common in the lower montane zone, as e. g. *Neanura verrucosa*, or *Onychiurus carpaticus*, — or even more widely distributed species, as e. g. *O. denisi*. It may be, that these species represent an ancient tertiary element in the fauna of mountains in Central Europe, and that it is possible to explain their lacking in our terrain by the activity of the Cracovian Glaciation (Mindel).

3. Boreal-alpine species (in the most general meaning) are species which occur in the North of Europe, whereas in Central Europe they occur only on mountains. Here belong:

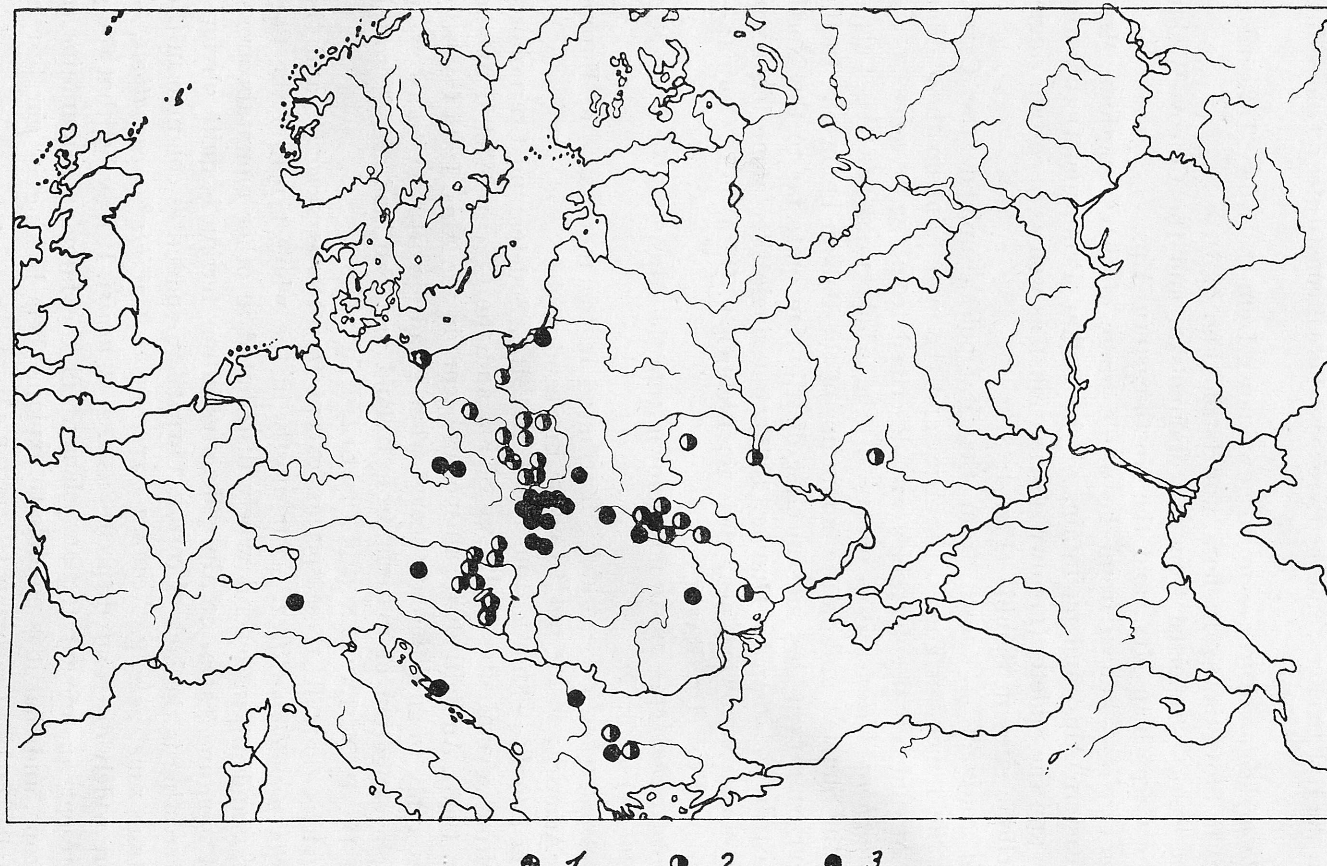


Fig. 4. Distribution of some species of *Collembola*. 1 — Ojców, 2 — *Orchesella multifasciata* STSCHERB. (with excluding of Asiatic localities), 3 — *Neanura carolii* (ST).

Hypogastrura sahlbergi — to date known from Slovakia, the Alps, Scandinavia, and Scotland.

Hypogastrura aequipilosa — known from southern Poland, the Eastern Carpathian Mts., Styria, and Arctica (Spitsbergen).

Xenylla brevicauda — known from the Carpathian Mts., the Alps, the Pyrenees, as well as from Scandinavia and Scotland.

Anurida granulata — up to now known from the Carpathian Mts., the Alps, and Scandinavia.

Tetracanthella arctica — known in Central Europe from the Tatra Mts., the Silesian Beskides, the Kłodzk basin, as well as from the Moravian Karst (Rusek, in litt.) and Moldavia (?) (Stegarescu, 1964, sub *T. wahlgreni*), and further on only from Spitzbergen, Greenland, and arctic Canada. An individual sub-species occurs in the Pyrenees (for map of distribution in Central Europe see: Cassagnau, 1959).

Anurophorus binoculatus (Ksen.) — up to now known from the Carpathian Mts., Sudetes and the Alps, as well as from northern Lapland and the island Jan Mayen (for distribution in Europe, see: Marcuzzi, 1963).

Tomocerus minutus — known from Scandinavia and the mountains of Central Europe. In connection with the possibility of mistaking it with the recently described *T. (T.) mixtus*, the including of this species in the Boreal-alpine species is quite uncertain.

Analogically as in the group of montane species, all Boreal-alpine forms, found in our terrain with exception of *Hypogastrura sahlbergi*, occur in the Carpathian Mts.

4. Southern species. This group includes species which occur only in Southern Europe, as well as more widely distributed species which in Central Europe don't reach far to the North. I include here:

Mesachorutes ojcoviensis — known from the Nietoperzowa cave near Ojców; reported also from a number of sites in Southern Europe (from Slovakia to the Pyrenees). Although these estimations may cause some doubts, the species is doubtless most closely related to the South-European forms.

Microgastrura duodecimoculata — known from several sites in Albania, Yugoslavia, Switzerland, as well as from the vicinity of Innsbruck, and lately reported also from Portugal (da Gama, 1964), southern France (Cassagnau, 1965) and Marocco (Lawrence, 1963) (Fig. 5; 4).

Neanura (Lathriopyga) phlegraea — widely distributed in Southern Europe; Ojców, and the vicinity of Zwierzyniec, near Zamość (my own observations); these are the sites of this species reaching farest to the North.

Tullbergia (Tullbergia) callipygos — widely distributed in Southern Europe; reported also from England and southern Sweden (Bödvarsson, 1963), as well as in South Africa (?).

Folsomides (Folsomides) parvulus — known from Poland (Pieprzowe Mts.), Podole, Hungary, Czechoslovakia, southern Germany, Switzerland, Portugal

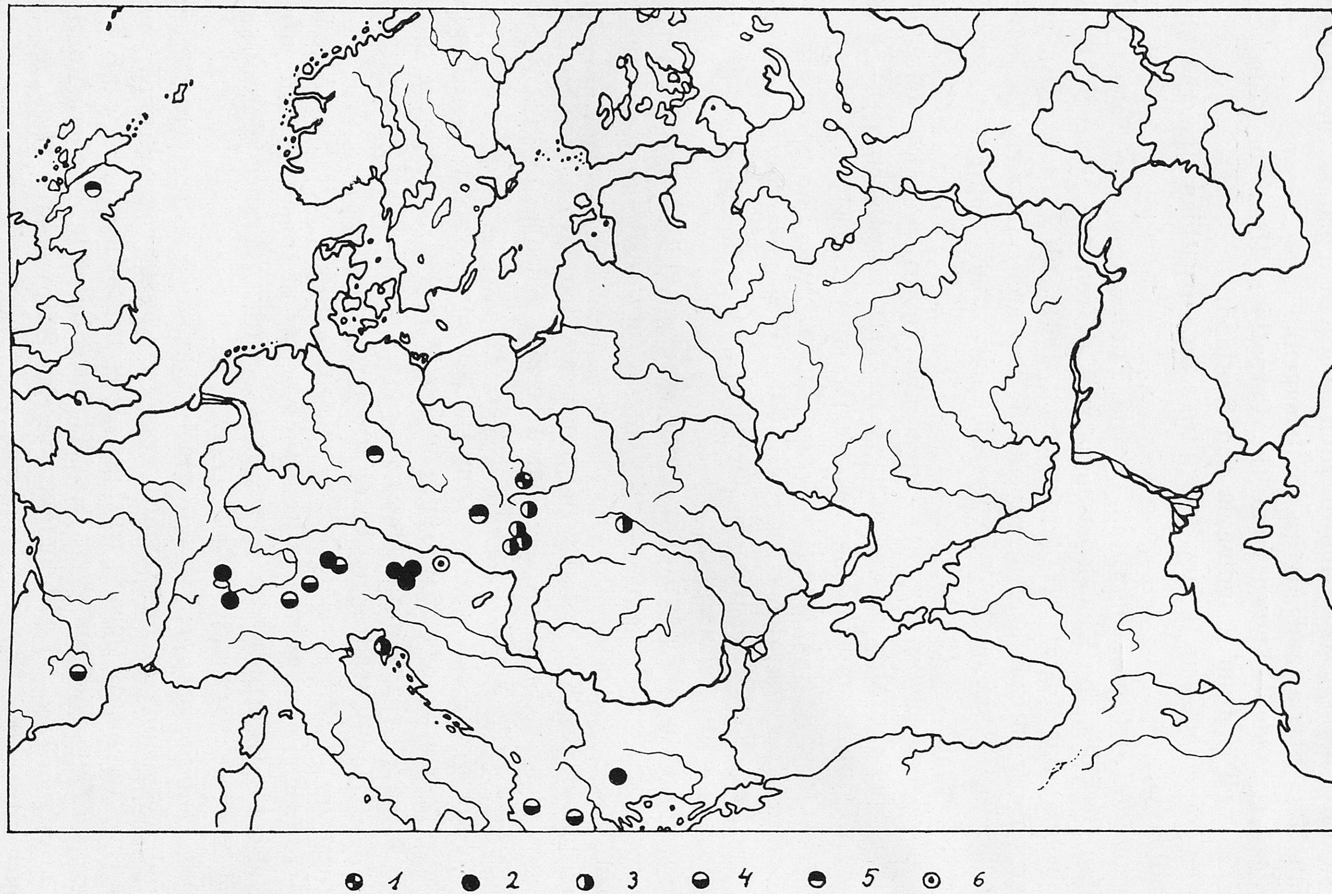


Fig. 5. Distribution of some species of *Collembola*. 1 — Ojców, 2 — *Onychiurus zschokkei* Hand., 3 — *Odontella pseudolamellifera* St., 4 — *Microgastrura duodecimoculata* St. (with exception of Portuguese and North African localities), 5 — *Sminthurinus flammeolus* Gis., 6 — *Isotomodes sexsetosus* da Gama.

(da Gama, 1964), the Azores (Paclt and Bödvarsson, 1961), southern Sweden (Bödvarsson, 1963), as well as North America.

Folsomia multiseta Stach — widely distributed in Southern Europe; also reported from North America.

Oncopodura crassicornis Schoeboth. — widely distributed in Southern and Western Europe where it reaches southern England.

Megalothorax incertus Börn. — widely distributed in Southern Europe; reported also from North America, Australia, and New Zealand.

Two of the species mentioned here, i. e. *Tullbergia callipygos*, and *Folsomides parvulus*, don't occur, as it seems, in the mountains of Central Europe. Both these species tend also in their distribution zones not as much towards the South, as rather to the Southwest (mediterranean-atlantic?).

Finally it seems necessary to stress the occurrence in the discussed area of certain rare species, which are known from very few sites only. Mentioning deserve first of all:

Isotomodes sexsetosus — reported from two sites in Austria (da Gama, 1964) (Fig. 5; 6).

Arrhopalites gisini — known only from the Bohemian Forest (Nosek, 1960).

Sminthurinus flammeolus — reported from Scotland and Thuringia (Gisin, 1961) and the Moravian Karst (Rusek, 1966) (Fig. 5; 5).

Discussing the Ojców fauna it is impossible to avoid mentioning the lack of certain species widely distributed and considered as very common. These are mainly: *Hypogastrura purpurascens*, *H. manubrialis*, *Podura aquatica*, and *Orchesella cincta*. Especially astonishing is the lack of the two latter species, as they are big and easy to notice in the field. *Podura aquatica* occurs already a few kilometres from the borders of the National Park on small overgrown by duckweed ponds on the plateau. However it does not occur on the flood waters of the Prądnik river. *Orchesella cincta* on the other hand, should be found after a more accurate investigation of the synanthropic habitats as it is a species which is in some of its distribution zones distinctly associated with man (see Schubert, 1933).

3. Notes on the history of fauna

The fauna of the southern part of the Cracow-Wieluń upland began its development certainly during the Great Interglaciation. For in spite of the possibility of existence of oases or nunataks in the glacier, up to now we have no fauna data which would supply evidence of the survival of any tertiary species. As I have already said in the introduction, since the time of the retreat of the Cracovian Glaciation (Mindel), the discussed area was already free of ice. And so, in spite of many climatical changes and several returns of the peryglacial climate, in an area morphologically so differentiated as our, doubtless prevailed microclimates which were favorable for the survival of interglacial forms. But

on the other hand, the prevalence of decidedly cold microclimates also favored the survival here of such forms, which arrived in one of the glaciations. This applies mainly to small forms which are able to live in very restricted areas, to which also springtails belong.

The assumption in the matter of survival of interglacial relicts in the southern Jura in relation to snails was favored by Urbański (1948), in relation to certain *Hepaticae* by Kornaś (1952), and in relation to mosses by Szafran (1955). Urbański associates the arrival of certain snail species with the Great Interglaciaton; the two remaining authors have one of the later interglaciations in mind. Anyhow, one may count on the existence of species which arrived here in connection with one of the interglaciations, and the last glaciation (or glaciations) survived.

Of the springtails, here may be taken into consideration the widely distributed species which in Central Europe don't reach far to the North, and which don't occur in Scandinavia [1]. These species extended probably during one of the interglaciations and were destroyed in the North by the last, or forelast glaciation. Here belong probably some of the above as southern mentioned species, namely: *Mesachorutes ojcoviensis*, *Neanura phlegraea*, *Folsomia multiseta*, *Oncopodura crassicornis*, and *Megalothorax incertus*. Of course, also other species may have survived the last glaciation here, if these species during the post-glacial period entered terrains farer northwards, — presently however it is impossible to state anything definite in this matter.

Besides this old interglacial element, in our terrain occurs the perhaps similarly old glacial element which is represented by some of the montane and Boreal-alpine species. Here belong: *Hypogastrura crassaeogranulata*, *Onychiurus zschokkei*, *Tetracanthella arctica*, and *Orchesella alticola*. These are species which occur in Central Europe above the upper timber line, and their occurrence in Ojców is of distinctly relictic character. Thus, they are distinctly stenotopic in our terrain, and restrict themselves to shaded, cool and moist rock parts. Only *Tetracanthella arctica* passes relatively often into warmer habitats. These species however are high up in the mountains markedly more eurytopic, and judging from literature, occur there in very differentiated habitats [2]. This group has certain analogies in the plant world. Szafer (1930) assumes that the period of migration of montane plants coincides not with the end of the last, but with one of the former glaciations. It seems that for the springtails mentioned here it would be correct to assume also one of the former glaciations, or at least the Older Dryas with the prevailing in the South of Poland arctic-montane tundra (Szafer, 1952). For these species are not only associated with habitats of a cold but also with those of a moist microclimate, and it seems, that the

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[1] It seems, that the degree of cognition of springtail fauna in northern Germany and Scandinavia permits already conclusions of this type.

[2] Ecological data: *Hypogastrura crassaeogranulata* — Nosek, 1964; *Onychiurus zschokkei* — Törne, 1958; *Tetracanthella arctica* — Stach, 1947 (sub *T. wahlgreni*); *Orchesella alticola* — Stach, 1960.

prevailing during the Younger Dryas continental tundra of the cold steppe type (ŚRODOŃ, 1959), was not favorable for this type of microclimate. Doubtless the forest barrier existing then in the Carpathian Mts. also prevented migration of high-montane forms. For the ancient distribution period in lower sites of *Hypogastrura crassaeogranulata* may also testify its marked differentiation of sub-species.

The end of the Pleistocene, the Younger Dryas, was also a period of migration for photophilous plants, and the arrival of steppe vegetation in our terrain is closely associated with it. One may probably associate also the arrival of the above mentioned widely distributed species, which however do not occur in the mountains, with this period. All these species are here associated with plots of xerothermic vegetation. Very characteristic for this group is the ecology of *Orchesella multifasciata*. This species occurs in southern Poland in more or less xerothermic sites, while in north-western Poland (Wolin, near Poznań; my own observations) it occurs also on the banks of water reservoirs and rivers whereto it was probably forced by the extention of forests. These species did not settle in the Carpathian Mts., as this area was already covered by forest in the Younger Dryas.

Microgastrura duodecimoculata is in our terrain a relict of the warm atlantic period (optimum of hazel). The species is in areas lying farther to the South quite eurytopic (TÖRNE, 1958), whereas in the Ojców area it is restricted to thermophilous brushwood *(Corylo-Peucedanetum)* and to warmer plots of mixed deciduous forest. Furthermore, the sites known up to date show that we deal here with a decidedly southern species. It may be, that with this warm period one ought to connect also the arrival of distinctly xerothermic *Folsomides parvulus*.

The moist and relatively cool period of the beech optimum (sub-Boreal) was a period where in the downlands numerous species of the lower montane zone were widely distributed. It was then that numerous montane species of animals (see e. g. URBAŃSKI, 1948) and plants (e. g. SZAFER, 1930) appeared in our terrain. Certainly also then arrived numerous species of springtails, namely montane species, except the previously mentioned high-montane forms, and surely most of the Boreal-alpine species. These species occur at present in Ojców in shaded forests, namely in beechstands *(Fagetum carpaticum)*. Among their number a distinctly relictic character of occurrence shows *Neanura carolii*. This species seems to be common in the whole lower montane zone of the Carpathian Mts., and according to my own observations from the vicinity of Krosno and Dukla occurs in various forest types. In the area of Ojców its occurrence is restricted only to the northern slopes of the Chełmowa Góra Mtn. and the lower part of the Jamka gorge, where it occurs in beechstands and in mixed forest with significant share of fir. This site is at the same moment a place of occurrence for very many plant species of the lower montane zone.

The last wave of species which settled in our terrain is for certain connected with the arrival of man here, and includes synanthropic species. For the mo-

ment I am able to mention here only *Hypogastrura viatica*, but after accurate investigation of the synanthropic habitats, certainly many more are to be found.

VII. CONCLUSIONS

1. In the area of the Ojców National Park the author found 157 species of springtails, 20 of which are new for the Polish fauna. Some of them are known up to date only from very few sites.

2. On hand of the constancy of species in various habitats, the author distinguishes 4 types of fauna: the fauna of saxicolous and xerothermic grassland, of umbriphilous saxicolous moss associations, the forest fauna, and the meadow fauna. The fauna of all forest types in the investigated area, including xerophilous brushwood, is nearly similar.

3. In relation to zoogeography the author discerns 4 groups of species. They are: widely distributed species, montane species, Boreal-alpine species, and southern species. The montane and Boreal-alpine species indicate close association of the fauna of the investigated area with the fauna of the Carpathian Mts.

4. On hand of species distribution and ecology of species in different distribution zones, the author distinguishes a number of relicts from various climatic periods. Glacial, interglacial, and relicts from the Younger Dryas originate from the Pleistocene; relicts from the atlantic periods and the sub-Boreal period derive from the Holocene.

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STRESZCZENIE

Praca niniejsza dotyczy fauny skoczogonek (*Collembola*) Ojcowskiego Parku Narodowego. Teren badań ograniczony jest w zasadzie przez granice Parku, poza nimi zbierana była tylko niewielka część materiałów. Obejmuje on więc część doliny Prądnika i Sąspówki, odchodzące od nich wąwozy i przyległe fragmenty wierzchowiny. Jest to teren geologicznie dość jednolity, posiada jednak, głównie dzięki rozwijającym się na wapiennym podłożu procesom krasowym, niesłychanie zróżnicowaną rzeźbę. Powoduje to wielkie zróżnicowanie mikroklimatów i środowisk, a więc i bogactwo flory i fauny.

Na badanym terenie stwierdzono występowanie 157 gatunków skoczogonek, z czego 20 gatunków jest nowych dla fauny Polski, a niektóre z nich były do-

tychczas znalezione tylko na niewielu stanowiskach, jak np. *Isotomodes sexsetosus*, *Sminthurinus flammeolus* czy *Arrhopalites gisini*. Dla gatunków zbieranych częściej określono ich stałość i liczebność względną (dominację) w glebach poszczególnych zespołów roślinnych.

Przy pomocy analizy częstości występowania gatunków w rozmaitych zespołach roślinnych wyróżniono 4 środowiska o jakościowo odmiennej faunie, to znaczy posiadające grupy własnych gatunków charakterystycznych. Są to: murawy naskalne i kserotermiczne, cieniolubne zespoły mszaków naskalnych, zespoły leśne i zaroślowe oraz łąki zajmujące dna dolin. Fauna leśna jest na terenie Ojcowa zaskakująco jednolita, prawie identyczne gatunki występują w zespołach tak różnych pod względem warunków ekologicznych jak np. ciepłe zarośla *(Corylo-Peucedanetum)* czy buczyna *(Fagetum carpaticum)*. Pewne różnice wykazują tylko porastające wierzchowinę bory mieszane. Z drugiej zaś strony, porównując faunę cienistych buczyn z różnych obszarów Europy można stwierdzić jej duże zróżnicowanie. Zaskakująca jest też odrębność fauny łąkowej, zwłaszcza wobec faktu, że łąki stanowią środowisko niewątpliwie sztuczne. Wynika ona, być może, ze znacznego wieku łąk.

Osobno omówiono zgrupowania gatunków występujących na roślinach oraz faunę jaskiń, brzegów zbiorników wodnych i faunę korolubną. W faunie jaskiń występują tylko dwa troglobionty: *Mesachorutes ojcoviensis* (tylko w jaskini Jerzmanowickiej) i *Arrhopalites pygmaeus*, oraz dwa troglofile: *Heteromurus nitidus* i *Folsomia listeri*. Pozostałe gatunki spotykane w jaskiniach należy uznać za mniej lub więcej przypadkowe troglokseny. Fauna brzegów zbiorników wodnych jest w porównaniu z niżem silnie zubożała, występuje w niej natomiast jeden gatunek związany z potokami górskimi, mianowicie *Hydroisotoma schaefferi*. Pod korą drzew zbierane były tylko pospolite w Europie środkowej kortikofile, nie występuje tu natomiast *Anurophorus laricis*, częsty w ściółce mieszanych borów.

W analizie zoogeograficznej, obok form o nieznanym bliżej rozmieszczeniu i rozsiedlonych bardzo szeroko, wyróżniono gatunki górskie, borealno-górskie i południowe. Wiele gatunków uznano za relikty z różnych okresów klimatycznych. Reliktami interglacjalnymi są gatunki szeroko rozsiedlone w południowej Europie, lecz w środkowej Europie nie sięgające daleko na północ — formy te rozprzestrzeniały się w którymś z interglacjałów. Reliktami glacjalnymi są gatunki występujące wysoko w górach w rozmaitych środowiskach, w niższych położeniach ograniczone jednak tylko do środowisk wilgotniejszych i chłodniejszych, a w Ojcowie występujące wyłącznie na chłodnych i wilgotnych ściankach skalnych. Tu należą: *Onychiurus zschokkei*, *Hypogastrura crassaeogranulata*, *Tetracanthella arctica* i *Orchesella alticola*. W młodszym Dryasie przybyły na nasz teren gatunki światłolubne, w Europie szeroko rozmieszczone, lecz nie występujące w pokrytych już w tym czasie lasem Karpatach. W Ojcowie występują one głównie w ciepłych i suchych murawach; ich przykładem może być *Orchesella multifasciata*. Z postglacjalnych okresów klimatycznych zaznacza się szczególnie silnie wpływ optimum buka. Wtedy to na nasz teren przybyło

wiele gatunków dolnoreglowych. Ich przykładem może być *Neanura carolii*, ograniczona na terenie Ojcowa wyłącznie do północnych stoków Chełmowej Góry i dolnych części Wąwozu Jamki. Słabiej nieco zaznacza się wpływ postglacjalnego optimum termicznego — reliktem z tego okresu jest zapewne *Microgastrura duodecimoculata*, gatunek w południowej Europie raczej eurytopowy, u nas natomiast ograniczony do ciepłych zarośli leszczynowych.

РЕЗЮМЕ

Настоящая работа посвящена фауне *Collembola* в Ойцовском национальном парке. Территория, на которой велись наблюдения, была ограничена в принципе пределами Парка; вне Парка было собрано лишь небольшое количество материалов. Исследуемая территория охватывала часть долины речек Прондник и Сонспувка, примыкающие к ней яры и смежные фрагменты плато. Данная территория является в принципе единой по своему геологическому строению, однако, главным образом благодаря карстовым процессам, происходящим в известняковых скалах, она обладает сильно дифференцированным рельефом, вызывающим значительное разнообразие микроклиматов и связанное с ним богатство флоры и фауны.

На исследуемой территории было обнаружено 157 видов *Collembola*, из которых 20 видов новы для фауны Польши, а некоторые из них были обнаружены всего в нескольких местах, например, *Isotomodes sexsetosus*, *Sminthurinus flammeolus* или *Arrhopalites gisini*. Для видов, встречаемых чаще, была установлена их стабильность и относительная численность (доминация) на почвах с разной растительностью.

С помощью анализа частоты появления исследуемых видов в разных растительных окружениях были выделены четыре типа среды, качественно отличающиеся друг от друга, то есть обладающие группами характерных для них видов. Это: наскальные и ксеротермические травы, наскальные мхи, расположенные в затененных местах, лес и кустарники и, наконец, луга, расположенные на дне долины. Лесная фауна на территории Ойцува вопреки ожиданиям едина; почти идентичны виды, обитающие в столь разных экологических условиях, как, например, теплые кустарники *(Corylo-Peucedanetum)* или буковый лес *(Fagetum carpaticum)*. Некоторым своеобразием обладают лишь смешанные леса, расположенные на плато. Если же учесть данные по фауне тенистых буковых лесов из разных районов Европы, то оказывается, что она всюду сильно дифференцирована. Интересно также своеобразие фауны лугов на исследуемой территории, в особенности, если учесть тот факт, что эти луга представляют собой несомненно искусственную среду. Это своеобразие связано, быть может, со значительным возрастом лугов.

Отдельно рассматривается в работе группа видов, обитающих на растениях,

а также фауна пещер, берегов водоемов и фауна коры. В фауне пещер встречаются всего лишь два троглобионта: *Mesachorutes ojcoviensis* (только в Ежмановицкой пещере) и *Arrhopalites pygmaeus*, а также два троглофила: *Heteromurus nitidus* и *Folsomia listeri*. Остальные виды, встречаемые в пещерах, следует считать более или менее случайными троглоксенами. Фауна берегов водоемов довольно убога; интересно наличие в ней одного вида, связанного с горными ручьями, а именно *Hydroisotoma schaefferi*. Под корой деревьев были обнаружены лишь распространенные в Средней Европе кортикофилы. Не был замечен *Anurophorus laritis*, часто встречаемый в смешанных лесах.

Зоогеографический анализ дал возможность выделить, кроме видов, обитающих в самых разных районах, виды горные, северно-горные и южные. Многие виды были признаны реликтами разных климатических периодов. Межледниковыми реликтами являются виды, представленные широко в Южной Европе, но малораспостраненные на севере Средней Европы. Эти формы распространились в Ойцуве в один из межледниковых периодов. Реликтами ледниковой эпохи являются виды, распространенные высоко в горах и встречаемые ниже лишь в холодных и сырых местах; в Ойцуве они встречаются лишь на сырых и холодных стенах скал. Сюда относятся: *Onychiurus zschokkei*, *Hypogastrura crassaeogranulata*, *Tetracanthella arctica* и *Orchesella alticola*. К младшему дриасу относится появление на территории Ойцува видов, обитавших в согреваемых солнцем местах; эти виды были широко распространены в Европе, но не обитали в покрытых тогда лесами Карпатах. В Ойцуве они обитают главным образом в сухой, согреваемой солнцем траве; примером может здесь послужить *Orchesella multifasciata*. В послеледниковый период на исследуемой территории обозначилось влияние оптимума бука. Именно тогда появился здесь ряд видов, связанных с лесами нижнегорной полосы. Примером их является *Neanura carolii*, распространение которой в Ойцуве ограничивается северными склонами Хелмовой горы и нижними районами Яра Ямки. Менее заметно влияние послеледникового термического оптимума; реликт этого периода представляет собою, вероятно, *Microgastrura duodecimoculata*, являющаяся в Южной Европе скорее евротипным видом, а у нас встречаемая лишь в теплых кустарниках орешника.

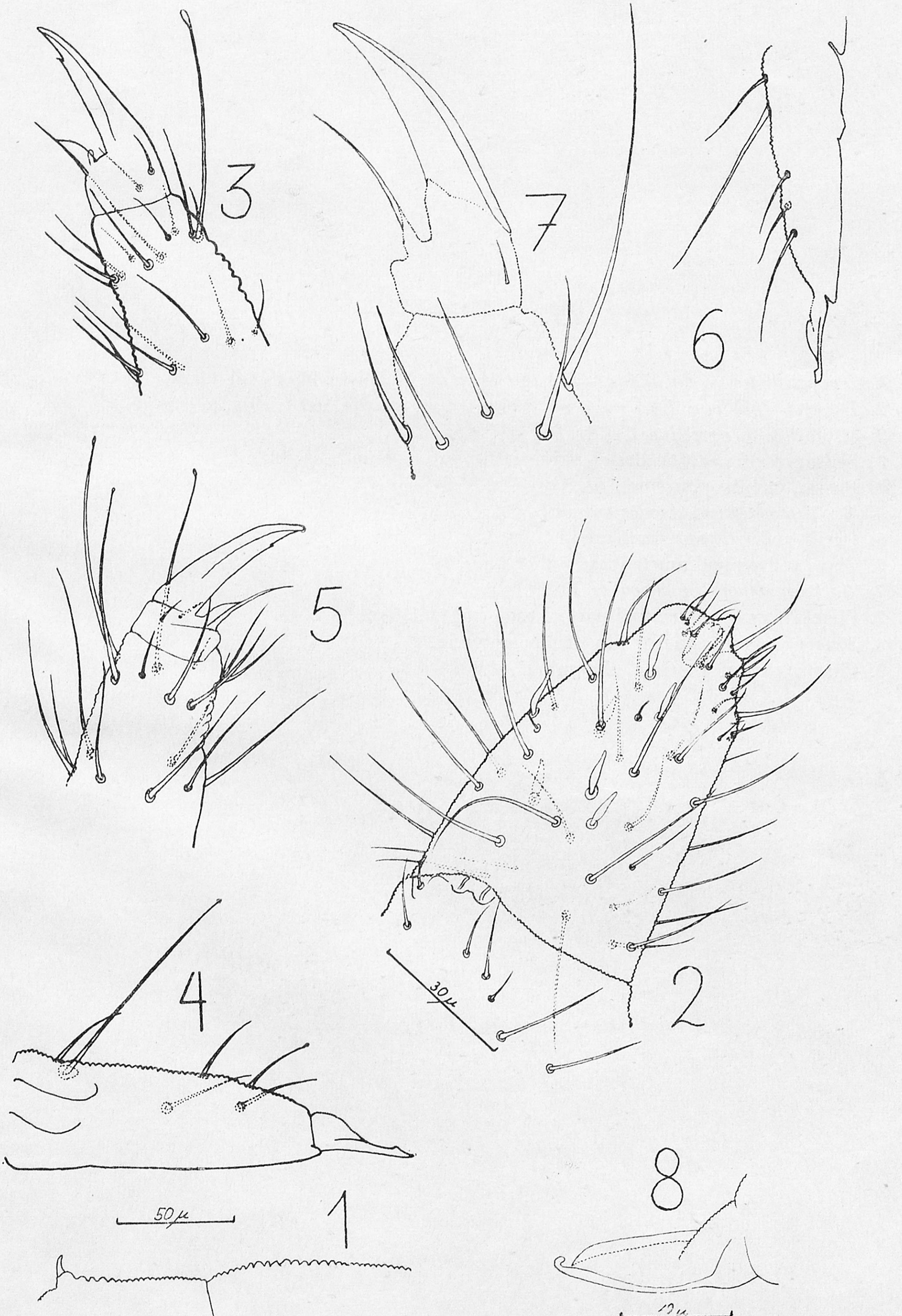
PLATES

Plate XVII

1—4. *Hypogastrura crassaeogranulata* (St.).
1. Granulation of the skin on the last abdominal terga.
2. Distal part of the antenna.
3. Distal part of the third leg (enlargment as 2).
4. Dens and mucro (enl. as 2).

5—6. *Hypogastrura aequipilosa* (St.).
5. Distal part of the third leg (enl. as 2).
6. Dens and mucro (enl. as 2).

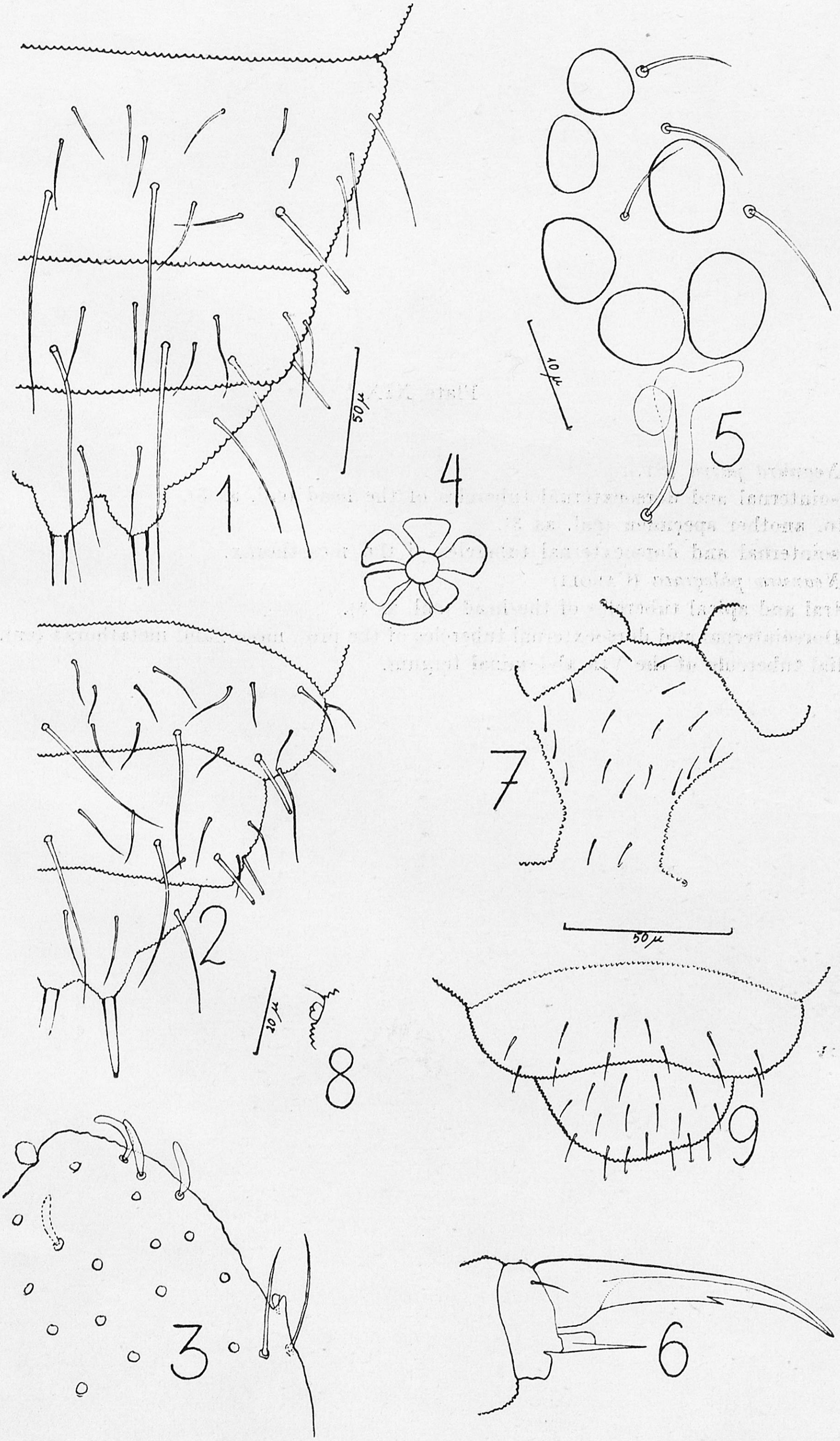
7—8. *Hypogastrura sahlbergi* (Reut.).
7. Distal part of the second leg (enl. as 8).
8. Mucro.



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Plate XVIII

1. *Hypogastrura armata* NIC. — chaetotaxy of the last abdominal terga.
2. *Hypogastrura engadinensis* GIS. — chaetotaxy of the last abdominal terga.
3—4. *Willemia scandinavica* ST.
3. Sensory setae of the distal part of the antenna (enl. as 5).
4. Postantennal organ (enl. as 5).
5—6. *Microgastrura duodecimoculata* ST.
5. Ocelli and postantennal organ
6. Claw and empodium (enl. as 5).
7—9. *Pseudachorutes parvulus* BÖRN.
7. Chaetotaxy of the medial part of the head (enl. as 9).
8. Sensory papilla on the tip of the antenna.
9. Chaetotaxy of the last abdominal terga.



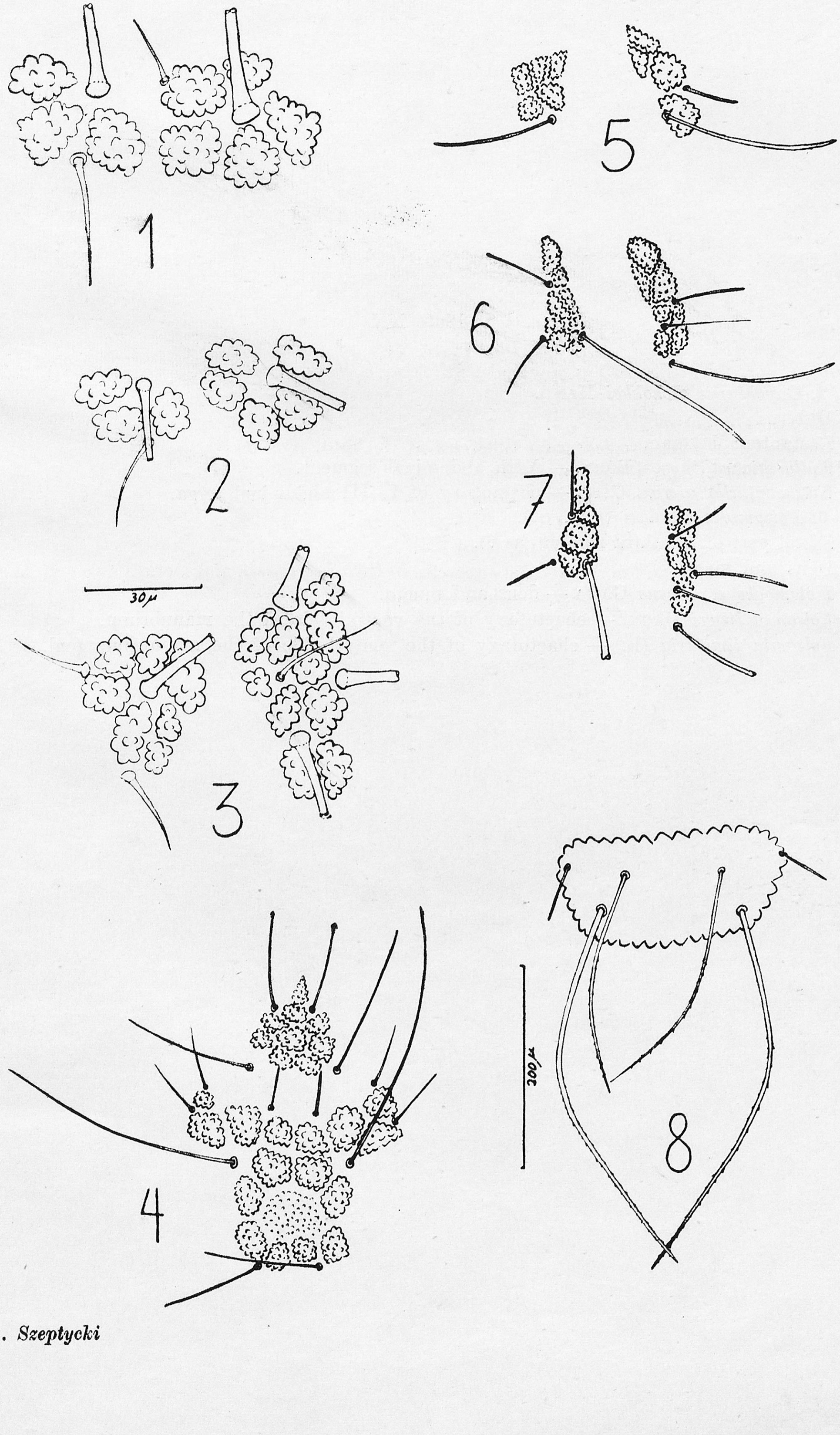
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Plate XIX

1—3. *Neanura parva* (St.).
1. Dorsointernal and dorsoexternal tubercles of the head (enl. as 3).
2. Ditto, another specimen (enl. as 3).
3. Dorsointernal and dorsoexternal tubercles of the mesothorax.

4—8. *Neanura phlegraea* (Caroli)
4. Central and apical tubercles of the head (enl. as 8).

5—7. Dorsointernal and dorsoexternal tubercles of the pro-, meso-, and metathorax (enl. as 8).
8. Medial tubercule of the Vth abdominal tergum.

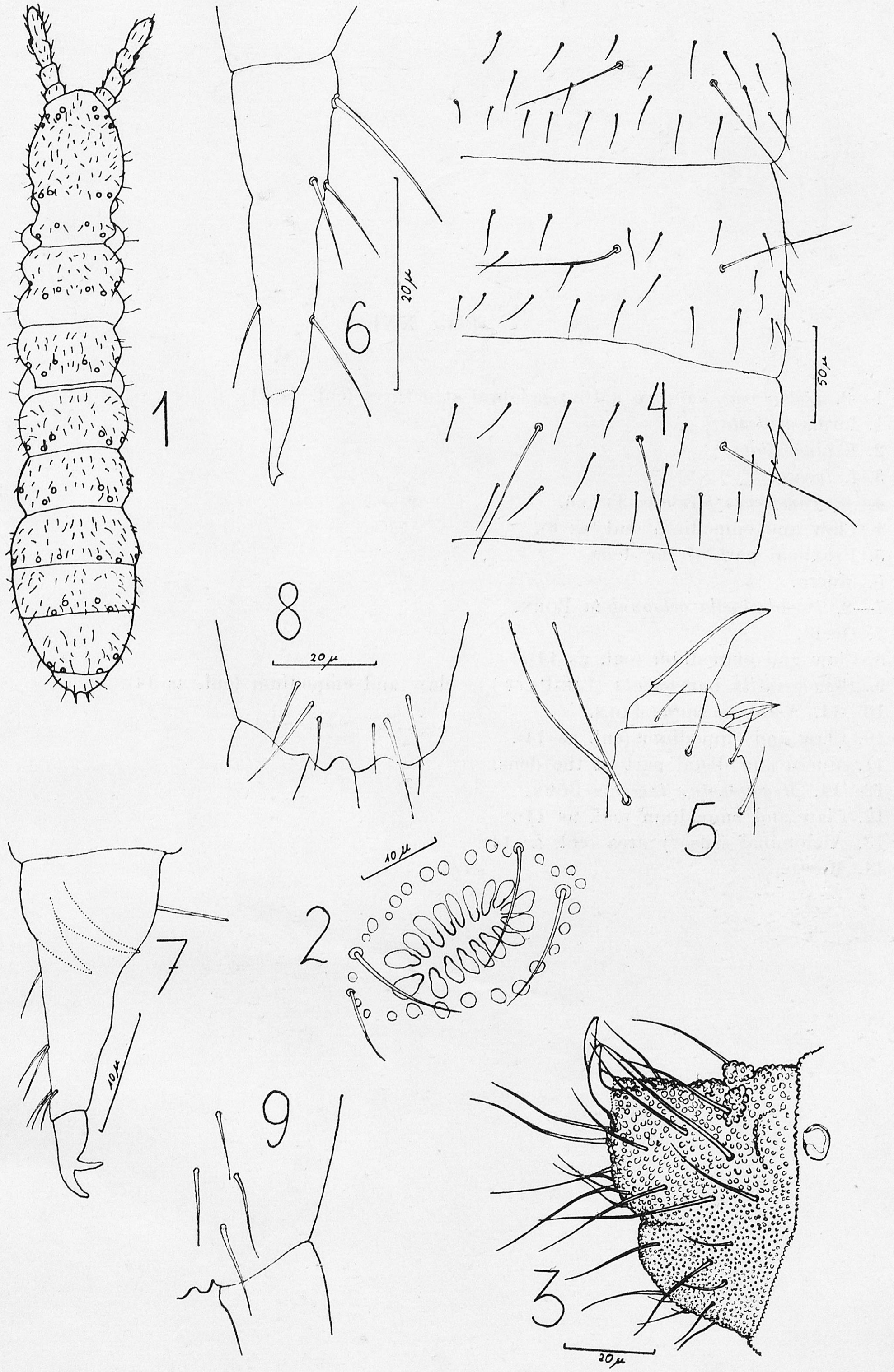


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Plate XX

1—2. *Onychiurus zschokkei* Hand.
1. Habitus
2. Postantennal organ.
3. *Tullbergia callipygos* Börn. — VIth abdominal segment.
4. *Tetracanthella arctica* Cass. — chaetotaxy of I—III abdominal terga.

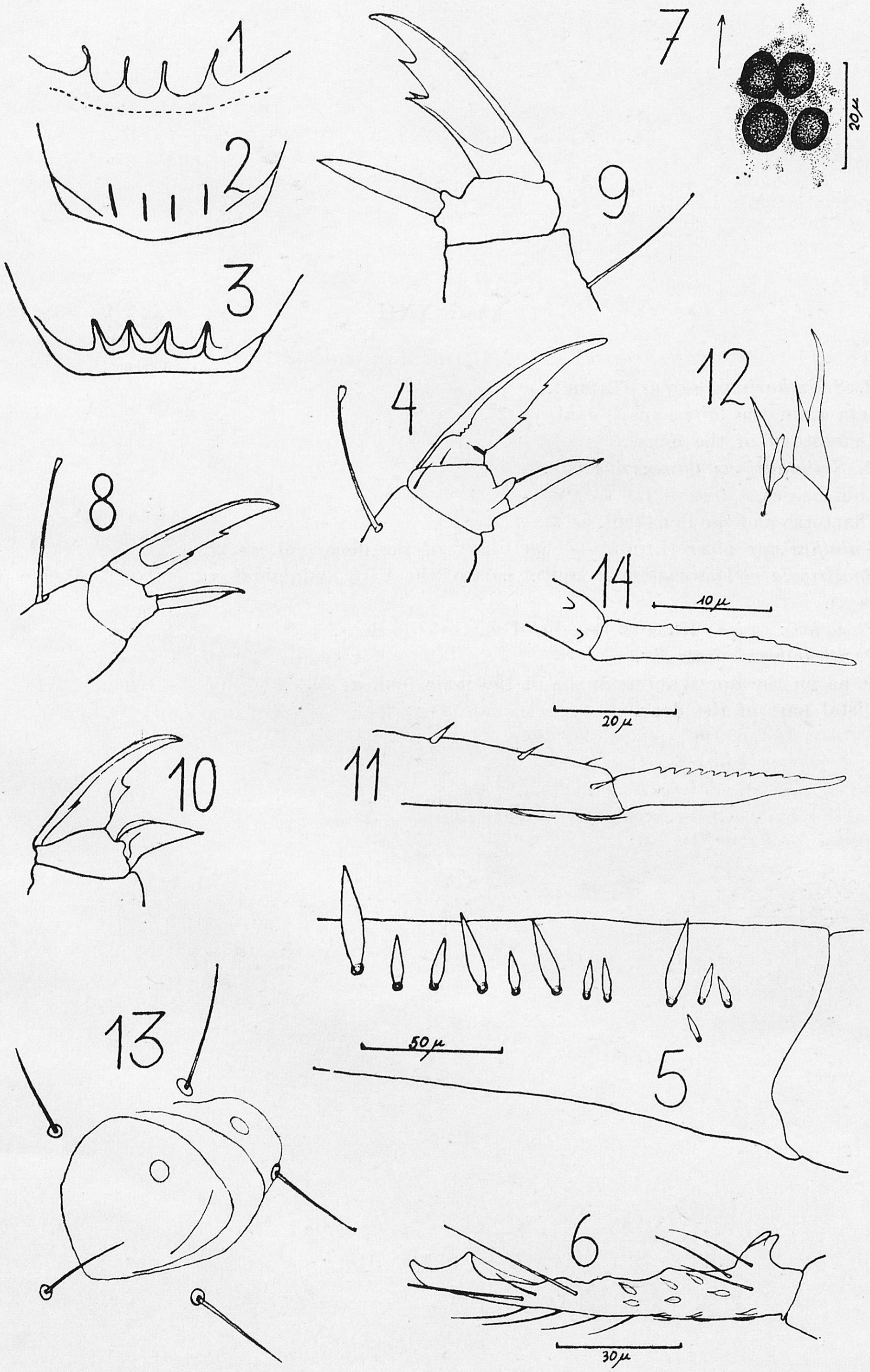
5—6. *Folsomides pusillus* (Schäff.).
5. Distal part of the third leg (enl. as 6).
6. Dens and mucro.
7. *Isotomodes sexsetosus* Gama — dens and mucro.
8. *Folsomia listeri* Bagn. — chaetotaxy of the ventral side of the manubrium.
9. *Folsomia fimetaria* (L.) — chaetotaxy of the ventral side of the manubrium (enl. as 8).



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Plate XXI

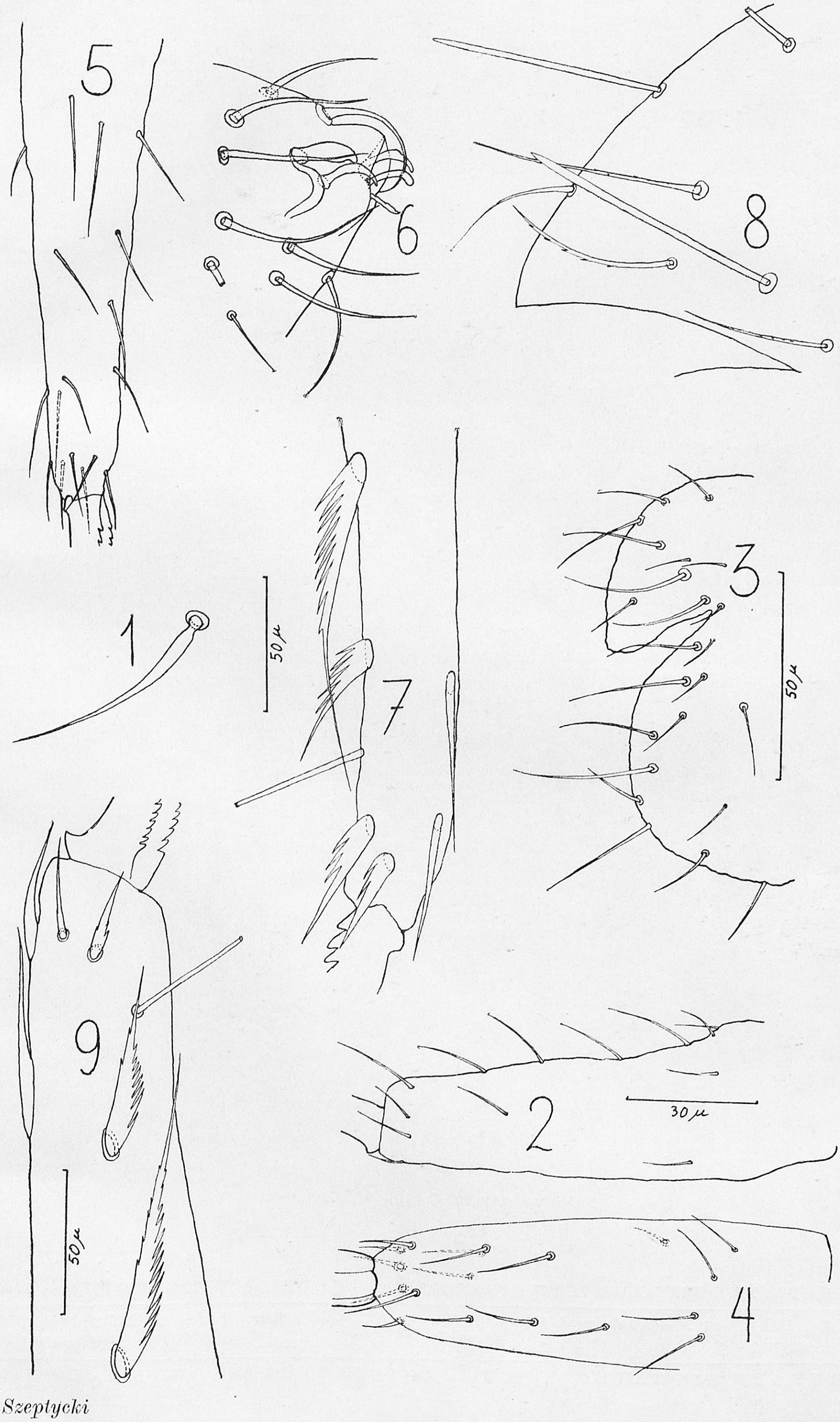
1—3. *Isotomurus palustris* (MÜLL.), labral structures (enl. as 11).
1. forma *balteata*.
2. f. *bimaculata*.
3. f. *fucata*.
4—6. *Tomocerus minutus* TULLB.
4. Claw and empodium (enl. as 6).
5. Proximal part of the dens.
6. Mucro.
7—8. *Pseudosinella octopunlata* BÖRN.
7. Ocelli.
8. Claw and empodium (enl. as 14).
9. *Pseudosinella immaculata* (LIE-PETT.) — claw and empodium (enl. as 14).
10—11. *Neelus minutus* FOLS.
10. Claw and empodium (enl. as 14).
11. Mucro and distal part of the dens.
12—14. *Megalothorax incertus* BÖRN.
12. Claw and empodium (enl. as 14).
13. Abdominal sensory area (enl. as 14).
14. Mucro.



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Plate XXII

1—2. *Sminthurinus aureus* (Lubb.).
1. Seta from the lobus analis (enl. as 2).
2. Chaetotaxy of the dens.
3—4. *Sminthurinus flammeolus* Gis.
3. Lobi anales
4. Chaetotaxy of the dens (enl. as 2).
5. *Sminthurinus niger* (Lubb.) — chaetotaxy of the dens (enl. as 2).
6. *Bourletiella viridescens* St. — apical part of the VIth abdominal segment of the male (enl. as 2).
7. *Ptenothrix setosa* (Krausb.) — distal part of the dens.
8—9. *Ptenothrix ciliata* St.
8. Setae on the dorsal lobus analis of the male (enl. as 9).
9. Distal part of the dens.



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